

WE CLAIM:

1. A method of detecting a nucleic acid having at least two portions comprising:

5 providing a type of nanoparticles having oligonucleotides attached thereto, the oligonucleotides on each nanoparticle having a sequence complementary to the sequence of at least two portions of the nucleic acid;

contacting the nucleic acid and the nanoparticles under conditions effective to allow hybridization of the oligonucleotides on the nanoparticles with the two or more portions of the nucleic acid; and

10 observing a detectable change brought about by hybridization of the oligonucleotides on the nanoparticles with the nucleic acid.

2. A method of detecting nucleic acid having at least two portions comprising:

15 contacting the nucleic acid with at least two types of nanoparticles having oligonucleotides attached thereto, the oligonucleotides on the first type of nanoparticles having a sequence complementary to a first portion of the sequence of the nucleic acid, the oligonucleotides on the second type of nanoparticles having a sequence complementary to a second portion of the sequence of the nucleic acid, the contacting
20 taking place under conditions effective to allow hybridization of the oligonucleotides on the nanoparticles with the nucleic acid; and

observing a detectable change brought about by hybridization of the oligonucleotides on the nanoparticles with the nucleic acid.

25 3. The method of Claim 2 wherein the contacting conditions include freezing and thawing.

4. The method of Claim 2 wherein the contacting conditions include heating.

5. The method of Claim 2 wherein the detectable change is observed on a solid surface.

5 6. The method of Claim 2 wherein the detectable change is a color change observable with the naked eye.

7. The method of Claim 6 wherein the color change is observed on a solid surface.

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8. The method of Claim 2 wherein the nanoparticles are made of gold.

9. The method of Claim 2 wherein the oligonucleotides attached to the nanoparticles are labeled on their ends not attached to the nanoparticles with molecules
15 that produce a detectable change upon hybridization of the oligonucleotides on the nanoparticles with the nucleic acid.

10. The method of Claim 9 wherein the nanoparticles are metallic or semiconductor nanoparticles and the oligonucleotides attached to the nanoparticles are
20 labeled with fluorescent molecules.

11. The method of Claim 2 wherein:
the nucleic acid has a third portion located between the first and second portions, and the sequences of the oligonucleotides on the nanoparticles do not include
25 sequences complementary to this third portion of the nucleic acid; and

the nucleic acid is further contacted with a filler oligonucleotide having a sequence complementary to this third portion of the nucleic acid, the contacting taking place under conditions effective to allow hybridization of the filler oligonucleotide with

the nucleic acid.

12. The method of Claim 2 wherein the nucleic acid is viral RNA or DNA.
13. The method of Claim 2 wherein the nucleic acid is a gene associated with
5 a disease.
14. The method of Claim 2 wherein the nucleic acid is a bacterial DNA.
15. The method of Claim 2 wherein the nucleic acid is a fungal DNA.
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16. The method of Claim 2 wherein the nucleic acid is a synthetic DNA, a
synthetic RNA, a structurally-modified natural or synthetic RNA, or a structurally-
modified natural or synthetic DNA.
17. The method of Claim 2 wherein the nucleic acid is from a biological
15 source.
18. The method of Claim 2 wherein the nucleic acid is a product of a
polymerase chain reaction amplification.
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19. The method of Claim 2 wherein the nucleic acid is contacted with the first
and second types of nanoparticles simultaneously.
20. The method of Claim 2 wherein the nucleic acid is contacted and
25 hybridized with the oligonucleotides on the first type of nanoparticles before being
contacted with the second type of nanoparticles.
21. The method of Claim 20 wherein the first type of nanoparticles is attached

to a substrate.

22. The method of Claim 2 wherein the nucleic acid is double-stranded and hybridization with the oligonucleotides on the nanoparticles results in the production of a
5 triple-stranded complex.

23. A method of detecting nucleic acid having at least two portions comprising:

providing a substrate having a first type of nanoparticles attached thereto,
10 the nanoparticles having oligonucleotides attached thereto, the oligonucleotides having a sequence complementary to a first portion of the sequence of a nucleic acid to be detected;

contacting said nucleic acid with the nanoparticles attached to the substrate under conditions effective to allow hybridization of the oligonucleotides on the
15 nanoparticles with said nucleic acid;

providing a second type of nanoparticles having oligonucleotides attached thereto, the oligonucleotides having a sequence complementary to one or more other portions of the sequence of said nucleic acid;

contacting said nucleic acid bound to the substrate with the second type of
20 nanoparticles under conditions effective to allow hybridization of the oligonucleotides on the second type of nanoparticles with said nucleic acid; and

observing a detectable change.

24. The method of Claim 23 wherein the substrate has a plurality of types of
25 nanoparticles attached to it in an array to allow for the detection of multiple portions of a single nucleic acid, the detection of multiple different nucleic acids, or both.

25. A method of detecting nucleic acid having at least two portions

comprising:

providing a substrate having a first type of nanoparticles attached thereto, the nanoparticles having oligonucleotides attached thereto, the oligonucleotides having a sequence complementary to a first portion of the sequence of a nucleic acid to be
5 detected;

contacting said nucleic acid with the nanoparticles attached to the substrate under conditions effective to allow hybridization of the oligonucleotides on the nanoparticles with said nucleic acid;

providing a second type of nanoparticles having oligonucleotides attached
10 thereto, the oligonucleotides having a sequence complementary to one or more other portions of the sequence of said nucleic acid;

contacting said nucleic acid bound to the substrate with the second type of nanoparticles under conditions effective to allow hybridization of the oligonucleotides on the second type of nanoparticles with said nucleic acid;

15 providing a binding oligonucleotide having a selected sequence having at least two portions, the first portion being complementary to at least a portion of the sequence of the oligonucleotides on the second type of nanoparticles;

contacting the binding oligonucleotide with the second type of nanoparticles bound to the substrate under conditions effective to allow hybridization of
20 the binding oligonucleotide to the oligonucleotides on the nanoparticles;

providing a third type of nanoparticles having oligonucleotides attached thereto, the oligonucleotides having a sequence complementary to the sequence of a second portion of the binding oligonucleotide;

contacting the third type of nanoparticles with the binding oligonucleotide
25 bound to the substrate under conditions effective to allow hybridization of the binding oligonucleotide to the oligonucleotides on the nanoparticles; and

observing a detectable change.

26. The method of Claim 25 wherein the substrate has a plurality of types of nanoparticles attached to it in an array to allow for the detection of multiple portions of a single nucleic acid, the detection of multiple different nucleic acids, or both.

5 27. A method of detecting nucleic acid having at least two portions comprising:

 contacting a nucleic acid to be detected with a substrate having oligonucleotides attached thereto, the oligonucleotides having a sequence complementary to a first portion of the sequence of said nucleic acid, the contacting taking place under
10 conditions effective to allow hybridization of the oligonucleotides on the substrate with said nucleic acid;

 contacting said nucleic acid bound to the substrate with a first type of nanoparticles having one or more types of oligonucleotides attached thereto, at least one of the types of oligonucleotides having a sequence complementary to a second portion of
15 the sequence of said nucleic acid, the contacting taking place under conditions effective to allow hybridization of the oligonucleotides on the nanoparticles with said nucleic acid;

 contacting the first type of nanoparticles bound to the substrate with a second type of nanoparticles having oligonucleotides attached thereto, the oligonucleotides on the second type of nanoparticles having a sequence complementary
20 to at least a portion of the sequence of one of the types of oligonucleotides on the first type of nanoparticles, the contacting taking place under conditions effective to allow hybridization of the oligonucleotides on the first and second types of nanoparticles; and
 observing a detectable change.

25 28. The method of Claim 27 wherein the first type of nanoparticles has only one type of oligonucleotides attached thereto, the oligonucleotides having a sequence complementary to the second portion of the sequence of said nucleic acid and to at least a portion of the sequence of the oligonucleotides on the second type of nanoparticles.

29. The method of Claim 28 further comprising contacting the second type of nanoparticles bound to the substrate with the first type of nanoparticles, the contacting taking place under conditions effective to allow hybridization of the oligonucleotides on
5 the first and second types of nanoparticles.

30. The method of Claim 27 wherein the first type of nanoparticles has at least two types of oligonucleotides attached thereto, the first type of oligonucleotides having a sequence complementary to the second portion of the sequence of said nucleic acid, and
10 the second type of oligonucleotides having a sequence complementary to the sequence of at least a portion of the oligonucleotides on the second type of nanoparticles.

31. The method of Claim 30 further comprising contacting the second type of nanoparticles bound to the substrate with the first type of nanoparticles, the contacting
15 taking place under conditions effective to allow hybridization of the oligonucleotides on the first and second types of nanoparticles.

32. The method of Claim 27 wherein the substrate has a plurality of types of oligonucleotides attached to it in an array to allow for the detection of multiple portions
20 of a single nucleic acid, the detection of multiple different nucleic acids, or both.

33. The method of any one of Claims 23-32 wherein the substrate is a transparent substrate or an opaque white substrate.

25 34. The method of Claim 33 wherein the detectable change is the formation of dark areas on the substrate.

35. The method of any one of Claims 23-32 wherein the nanoparticles are

made of gold.

36. The method of any one of Claims 23-32 wherein the substrate is contacted with silver stain to produce the detectable change.

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37. The method of any one of Claims 23-32 wherein the detectable change is observed with an optical scanner.

38. A method of detecting nucleic acid having at least two portions
10 comprising:

contacting a nucleic acid to be detected with a substrate having
oligonucleotides attached thereto, the oligonucleotides having a sequence complementary
to a first portion of the sequence of said nucleic acid, the contacting taking place under
conditions effective to allow hybridization of the oligonucleotides on the substrate with
15 said nucleic acid;

contacting said nucleic acid bound to the substrate with a type of
nanoparticles having oligonucleotides attached thereto, the oligonucleotides having a
sequence complementary to a second portion of the sequence of said nucleic acid, the
contacting taking place under conditions effective to allow hybridization of the
20 oligonucleotides on the nanoparticles with said nucleic acid;

contacting the substrate with silver stain to produce a detectable change;
and

observing the detectable change.

25 39. The method of Claim 38 wherein the nanoparticles are made of a noble metal.

40. The method of Claim 39 wherein the nanoparticles are made of gold or silver.

41. The method of Claim 38 wherein the substrate has a plurality of types of oligonucleotides attached to it in an array to allow for the detection of multiple portions of a single nucleic acid, the detection of multiple different nucleic acids, or both.

5 42. The method of any one of Claims 38-41 wherein the detectable change is observed with an optical scanner.

43. A method of detecting nucleic acid having at least two portions comprising:

10 contacting a nucleic acid to be detected with a substrate having oligonucleotides attached thereto, the oligonucleotides having a sequence complementary to a first portion of the sequence of said nucleic acid, the contacting taking place under conditions effective to allow hybridization of the oligonucleotides on the substrate with said nucleic acid;

15 contacting said nucleic acid bound to the substrate with liposomes having oligonucleotides attached thereto, the oligonucleotides having a sequence complementary to a portion of the sequence of said nucleic acid, the contacting taking place under conditions effective to allow hybridization of the oligonucleotides on the liposomes with said nucleic acid;

20 contacting the liposomes bound to the substrate with a first type of nanoparticles having at least a first type oligonucleotides attached thereto, the first type of oligonucleotides having a hydrophobic group attached to the end not attached to the nanoparticles, the contacting taking place under conditions effective to allow attachment of the oligonucleotides on the nanoparticles to the liposomes as a result of hydrophobic
25 interactions; and

observing a detectable change.

44. A method of detecting nucleic acid having at least two portions

comprising

contacting a nucleic acid to be detected with a substrate having oligonucleotides attached thereto, the oligonucleotides having a sequence complementary to a first portion of the sequence of said nucleic acid, the contacting taking place under conditions effective to allow hybridization of the oligonucleotides on the substrate with said nucleic acid;

contacting said nucleic acid bound to the substrate with liposomes having oligonucleotides attached thereto, the oligonucleotides having a sequence complementary to a portion of the sequence of said nucleic acid, the contacting taking place under conditions effective to allow hybridization of the oligonucleotides on the liposomes with said nucleic acid;

contacting the liposomes bound to the substrate with a first type of nanoparticles having at least a first type oligonucleotides attached thereto, the first type of oligonucleotides having a hydrophobic group attached to the end not attached to the nanoparticles, the contacting taking place under conditions effective to allow attachment of the oligonucleotides on the nanoparticles to the liposomes as a result of hydrophobic interactions;

contacting the first type of nanoparticles bound to the liposomes with a second type of nanoparticles having oligonucleotides attached thereto,

the first type of nanoparticles having a second type of oligonucleotides attached thereto which have a sequence complementary to at least a portion of the sequence of the oligonucleotides on the second type of nanoparticles,

the oligonucleotides on the second type of nanoparticles having a sequence complementary to at least a portion of the sequence of the second type of oligonucleotides on the first type of nanoparticles,

the contacting taking place under conditions effective to allow hybridization of the oligonucleotides on the first and second types of nanoparticles; and observing a detectable change.

45. The method of Claim 43 or 44 wherein the substrate has a plurality of types of oligonucleotides attached to it in an array to allow for the detection of multiple portions of a single nucleic acid, the detection of multiple different nucleic acids, or both.

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46. The method of Claim 43 or 44 wherein the nanoparticles are made of gold.

47. The method of Claim 43 or 44 wherein the substrate is contacted with silver stain to produce the detectable change.

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48. The method of any one of Claims 43 or 44 wherein the detectable change is observed with an optical scanner.

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49. A method of detecting nucleic acid having at least two portions comprising:

providing a substrate having a first type of nanoparticles attached thereto, the nanoparticles having oligonucleotides attached thereto, the oligonucleotides having a sequence complementary to a first portion of the sequence of a nucleic acid to be detected;

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contacting said nucleic acid with the nanoparticles attached to the substrate under conditions effective to allow hybridization of the oligonucleotides on the nanoparticles with said nucleic acid;

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providing an aggregate probe comprising at least two types of nanoparticles having oligonucleotides attached thereto, the nanoparticles of the aggregate probe being bound to each other as a result of the hybridization of some of the oligonucleotides attached to them, at least one of the types of nanoparticles of the aggregate probe having oligonucleotides attached thereto which have a sequence complementary to a second portion of the sequence of said nucleic acid;

contacting said nucleic acid bound to the substrate with the aggregate probe under conditions effective to allow hybridization of the oligonucleotides on the aggregate probe with said nucleic acid; and
observing a detectable change.

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50. The method of Claim 49 wherein the substrate has a plurality of types of nanoparticles attached to it in an array to allow for the detection of multiple portions of a single nucleic acid, the detection of multiple different nucleic acids, or both.

10 51. A method of detecting nucleic acid having at least two portions comprising:

providing a substrate having oligonucleotides attached thereto, the oligonucleotides having a sequence complementary to a first portion of the sequence of a nucleic acid to be detected;

15 providing an aggregate probe comprising at least two types of nanoparticles having oligonucleotides attached thereto, the nanoparticles of the aggregate probe being bound to each other as a result of the hybridization of some of the oligonucleotides attached to them, at least one of the types of nanoparticles of the aggregate probe having oligonucleotides attached thereto which have a sequence
20 complementary to a second portion of the sequence of said nucleic acid;

contacting said nucleic acid, the substrate and the aggregate probe under conditions effective to allow hybridization of said nucleic acid with the oligonucleotides on the aggregate probe and with the oligonucleotides on the substrate; and

observing a detectable change.

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52. The method of Claim 51 wherein said nucleic acid is contacted with the substrate so that said nucleic acid hybridizes with the oligonucleotides on the substrate, and said nucleic acid bound to the substrate is then contacted with the aggregate probe so

that said nucleic acid hybridizes with the oligonucleotides on the aggregate probe.

53. The method of Claim 51 wherein said nucleic acid is contacted with the aggregate probe so that said nucleic acid hybridizes with the oligonucleotides on the aggregate probe, and said nucleic acid bound to the aggregate probe is then contacted with the substrate so that said nucleic acid hybridizes with the oligonucleotides on the substrate.

54. The method of Claim 51 wherein said nucleic acid is contacted simultaneously with the aggregate probe and the substrate.

55. The method of Claim 51 wherein the substrate has a plurality of types of oligonucleotides attached to it in an array to allow for the detection of multiple portions of a single nucleic acid, the detection of multiple different nucleic acids, or both.

56. A method of detecting nucleic acid having at least two portions comprising:

providing a substrate having oligonucleotides attached thereto;
providing an aggregate probe comprising at least two types of nanoparticles having oligonucleotides attached thereto, the nanoparticles of the aggregate probe being bound to each other as a result of the hybridization of some of the oligonucleotides attached to them, at least one of the types of nanoparticles of the aggregate probe having oligonucleotides attached thereto which have a sequence complementary to a first portion of the sequence of a nucleic acid to be detected;

providing a type of nanoparticles having at least two types of oligonucleotides attached thereto, the first type of oligonucleotides having a sequence complementary to a second portion of the sequence of said nucleic acid, the second type of oligonucleotides having a sequence complementary to at least a portion of the

sequence of the oligonucleotides attached to the substrate;

contacting said nucleic acid, the aggregate probe, the nanoparticles and the substrate, the contacting taking place under conditions effective to allow hybridization of said nucleic acid with the oligonucleotides on the aggregate probe and on the nanoparticles and hybridization of the oligonucleotides on the nanoparticles with the oligonucleotides on the substrate; and
observing a detectable change.

57. The method of Claim 56 wherein said nucleic acid is contacted with the aggregate probe and the nanoparticles so that said nucleic acid hybridizes with the oligonucleotides on the aggregate probe and with the oligonucleotides on the nanoparticles, and said nucleic acid bound to the aggregate probe and nanoparticles is then contacted with the substrate so that the oligonucleotides on the nanoparticles hybridize with the oligonucleotides on the substrate.

58. The method of Claim 56 wherein said nucleic acid is contacted with the aggregate probe so that said nucleic acid hybridizes with the oligonucleotides on the aggregate probe, said nucleic acid bound to the aggregate probe is then contacted with the nanoparticles so that said nucleic acid hybridizes with the oligonucleotides on the nanoparticles, and said nucleic acid bound to the aggregate probe and nanoparticles is then contacted with the substrate so that the oligonucleotides on the nanoparticles hybridize with the oligonucleotides on the substrate.

59. The method of Claim 56 wherein said nucleic acid is contacted with the aggregate probe so that said nucleic acid hybridizes with the oligonucleotides on the aggregate probe, the nanoparticles are contacted with the substrate so that the oligonucleotides on the nanoparticles hybridize with the oligonucleotides on the substrate, and said nucleic acid bound to the aggregate probe is then contacted with the

nanoparticles bound to the substrate so that said nucleic acid hybridizes with the oligonucleotides on the nanoparticles.

5 60. The method of Claim 56 wherein the substrate has the oligonucleotides attached to it in an array to allow for the detection of multiple portions of a single nucleic acid, the detection of multiple different nucleic acids, or both.

10 61. The method of any one of Claims 49-60 wherein the substrate is a transparent substrate or an opaque white substrate.

62. The method of Claim 61 wherein the detectable change is the formation of dark areas on the substrate.

15 63. The method of any one of Claims 49-60 wherein the nanoparticles in the aggregate probe are made of gold.

64. The method of any one of Claims 49-60 wherein the substrate is contacted with a silver stain to produce the detectable change.

20 65. The method of any one of Claims 49-60 wherein the detectable change is observed with an optical scanner.

25 66. A method of detecting nucleic acid having at least two portions comprising:

contacting a nucleic acid to be detected with a substrate having oligonucleotides attached thereto, the oligonucleotides having a sequence complementary to a first portion of the sequence of said nucleic acid, the contacting taking place under conditions effective to allow hybridization of the oligonucleotides on the substrate with

said nucleic acid;

contacting said nucleic acid bound to the substrate with liposomes having oligonucleotides attached thereto, the oligonucleotides having a sequence complementary to a portion of the sequence of said nucleic acid, the contacting taking place under conditions effective to allow hybridization of the oligonucleotides on the liposomes with said nucleic acid;

providing an aggregate probe comprising at least two types of nanoparticles having oligonucleotides attached thereto, the nanoparticles of the aggregate probe being bound to each other as a result of the hybridization of some of the oligonucleotides attached to them, at least one of the types of nanoparticles of the aggregate probe having oligonucleotides attached thereto which have a hydrophobic group attached to the end not attached to the nanoparticles;

contacting the liposomes bound to the substrate with the aggregate probe under conditions effective to allow attachment of the oligonucleotides on the aggregate probe to the liposomes as a result of hydrophobic interactions; and observing a detectable change.

67. The method of Claim 66 wherein the nanoparticles in the aggregate probe are made of gold.

68. The method of Claim 66 wherein the substrate is contacted with a silver stain to produce the detectable change.

69. The method of Claim 66 wherein the substrate has a plurality of types of oligonucleotides attached to it in an array to allow for the detection of multiple portions of a single nucleic acid, the detection of multiple different nucleic acids, or both.

70. A method of detecting nucleic acid having at least two portions

comprising:

providing a substrate having oligonucleotides attached thereto, the oligonucleotides having a sequence complementary to a first portion of the sequence of a nucleic acid to be detected;

5 providing a core probe comprising at least two types of nanoparticles, each type of nanoparticles having oligonucleotides attached thereto which are complementary to the oligonucleotides on at least one of the other types of nanoparticles, the nanoparticles of the aggregate probe being bound to each other as a result of the hybridization of the oligonucleotides attached to them;

10 providing a type of nanoparticles having two types of oligonucleotides attached thereto, the first type of oligonucleotides having a sequence complementary to a second portion of the sequence of said nucleic acid, the second type of oligonucleotides having a sequence complementary to a portion of the sequence of the oligonucleotides attached to at least one of the types of nanoparticles of the core probe;

15 contacting said nucleic acid, the nanoparticles, the substrate and the core probe under conditions effective to allow hybridization of said nucleic acid with the oligonucleotides on the nanoparticles and with the oligonucleotides on the substrate and to allow hybridization of the oligonucleotides on the nanoparticles with the oligonucleotides on the core probe; and

20 observing a detectable change.

71. The method of Claim 70 wherein said nucleic acid is contacted with the substrate so that said nucleic acid hybridizes with the oligonucleotides on the substrate, and said nucleic acid bound to the substrate is then contacted with the nanoparticles so
25 that said nucleic acid hybridizes with the oligonucleotides on the nanoparticles, and the nanoparticles bound to said nucleic acid are contacted with the core probe so that the oligonucleotides on the core probe hybridize with the oligonucleotides on the nanoparticles.

72. The method of Claim 70 wherein said nucleic acid is contacted with the nanoparticles so that said nucleic acid hybridizes with the oligonucleotides on the nanoparticles, said nucleic acid bound to the nanoparticles is then contacted with the substrate so that said nucleic acid hybridizes with the oligonucleotides on the substrate,
5 and the nanoparticles bound to said nucleic acid are contacted with the core probe so that the oligonucleotides on the core probe hybridize with the oligonucleotides on the nanoparticles.

73. A method of detecting nucleic acid having at least two portions
10 comprising:

providing a substrate having oligonucleotides attached thereto, the oligonucleotides having a sequence complementary to a first portion of the sequence of a nucleic acid to be detected;

providing a core probe comprising at least two types of nanoparticles, each
15 type of nanoparticles having oligonucleotides attached thereto which are complementary to the oligonucleotides on at least one other type of nanoparticles, the nanoparticles of the aggregate probe being bound to each other as a result of the hybridization of the oligonucleotides attached to them;

providing a type of linking oligonucleotides comprising a sequence
20 complementary to a second portion of the sequence of said nucleic acid and a sequence complementary to a portion of the sequence of the oligonucleotides attached to at least one of the types of nanoparticles of the core probe;

contacting said nucleic acid, the linking oligonucleotides, the substrate and the core probe under conditions effective to allow hybridization of said nucleic acid with
25 the linking oligonucleotides and with the oligonucleotides on the substrate and to allow hybridization of the oligonucleotides on the linking oligonucleotides with the oligonucleotides on the core probe; and

observing a detectable change.

74. The method of any one of Claims 70-73 wherein the substrate has a plurality of types of oligonucleotides attached to it in an array to allow for the detection of multiple portions of a single nucleic acid, the detection of multiple different nucleic acids, or both.

75. The method of any one of Claims 70-73 wherein the substrate is a transparent substrate or an opaque white substrate.

76. The method of Claim 76 wherein the detectable change is the formation of dark areas on the substrate.

77. The method of any one of Claims 70-73 wherein the nanoparticles in the core probe are made of gold.

78. The method of any one of Claims 70-73 wherein the substrate is contacted with a silver stain to produce the detectable change.

79. The method of any one of Claims 70-73 wherein the detectable change is observed with an optical scanner.

80. A method of detecting a nucleic acid having at least two portions comprising:

providing nanoparticles having oligonucleotides attached thereto;
providing one or more types of binding oligonucleotides, each of the binding oligonucleotides having two portions, the sequence of one portion being complementary to the sequence of one of the portions of the nucleic acid and the sequence of the other portion being complementary to the sequence of the

oligonucleotides on the nanoparticles;

contacting the nanoparticles and the binding oligonucleotides under conditions effective to allow hybridization of the oligonucleotides on the nanoparticles with the binding oligonucleotides;

5 contacting the nucleic acid and the binding oligonucleotides under conditions effective to allow hybridization of the binding oligonucleotides with the nucleic acid; and

observing a detectable change.

10 81. The method of Claim 80 wherein the nanoparticles are contacted with the binding oligonucleotides prior to being contacted with the nucleic acid.

82. A method of detecting a nucleic acid having at least two portions comprising:

15 providing nanoparticles having oligonucleotides attached thereto;

providing one or more binding oligonucleotides, each of the binding oligonucleotides having two portions, the sequence of one portion being complementary to the sequence of at least two portions of the nucleic acid and the sequence of the other portion being complementary to the sequence of the oligonucleotides on the nanoparticles;

20 contacting the nanoparticles and the binding oligonucleotides under conditions effective to allow hybridization of the oligonucleotides on the nanoparticles with the binding oligonucleotides;

contacting the nucleic acid and the binding oligonucleotides under conditions effective to allow hybridization of the binding oligonucleotides with the nucleic acid; and

observing a detectable change.

83. A method of detecting nucleic acid having at least two portions comprising:

contacting the nucleic acid with at least two types of particles having oligonucleotides attached thereto,

5 the oligonucleotides on the first type of particles having a sequence complementary to a first portion of the sequence of the nucleic acid and being labeled with an energy donor,

the oligonucleotides on the second type of particles having a sequence complementary to a second portion of the sequence of the nucleic acid and being labeled
10 with an energy acceptor,

the contacting taking place under conditions effective to allow hybridization of the oligonucleotides on the particles with the nucleic acid; and

observing a detectable change brought about by hybridization of the oligonucleotides on the particles with the nucleic acid.

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84. The method of Claim 83 wherein the energy donor and acceptor are fluorescent molecules.

85. A method of detecting nucleic acid having at least two portions
20 comprising:

providing a type of microspheres having oligonucleotides attached thereto, the oligonucleotides having a sequence complementary to a first portion of the sequence of the nucleic acid and being labeled with a fluorescent molecule;

providing a type of nanoparticles having oligonucleotides attached thereto,
25 the oligonucleotides having a sequence complementary to a second portion of the sequence of the nucleic acid, nanoparticles being capable of producing a detectable change;

contacting the nucleic acid with the microspheres and the nanoparticles

under conditions effective to allow hybridization of the oligonucleotides on the microspheres and on the nanoparticles with the nucleic acid; and

observing a change in fluorescence, another detectable change produced by the nanoparticles, or both.

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86. The method of Claim 85 wherein the detectable change produced by the nanoparticles is a change in color.

87. The method of Claim 85 wherein the microspheres are latex microspheres
10 and the nanoparticles are gold nanoparticles, and changes in fluorescence, color or both are observed.

88. The method of Claim 87 further comprising placing a portion of the mixture of the latex microspheres, nanoparticles and nucleic acid in an observation area
15 located on a microporous material, treating the microporous material so as to remove any unbound gold nanoparticles from the observation area, and then observing the changes in fluorescence, color, or both.

89. A method of detecting nucleic acid having at least two portions
20 comprising:

providing a first type of metallic or semiconductor nanoparticles having oligonucleotides attached thereto, the oligonucleotides having a sequence complementary to a first portion of the sequence of the nucleic acid and being labeled with a fluorescent molecule;

25 providing a second type of metallic or semiconductor nanoparticles having oligonucleotides attached thereto, the oligonucleotides having a sequence complementary to a second portion of the sequence of the nucleic acid and being labeled with a fluorescent molecule;

contacting the nucleic acid with the two types of nanoparticles under conditions effective to allow hybridization of the oligonucleotides on the two types of nanoparticles with the nucleic acid; and

observing changes in fluorescence.

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90. The method of Claim 89 further comprising placing a portion of the mixture of the nanoparticles and nucleic acid in an observation area located on a microporous material, treating the microporous material so as to remove any unbound nanoparticles from the observation area, and then observing the changes in fluorescence.

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91. A method of detecting nucleic acid having at least two portions comprising:

providing a type of particle having oligonucleotides attached thereto, the oligonucleotides having a first portion and a second portion, both portions being complementary to portions of the sequence of the nucleic acid;

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providing a type of probe oligonucleotides comprising a first portion and a second portion, the first portion having a sequence complementary to the first portion of the oligonucleotides attached to the particles and both portions being complementary to portions of the sequence of the nucleic acid, the probe oligonucleotides further being labeled with a reporter molecule at one end;

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contacting the particle and the probe oligonucleotides under conditions effective to allow for hybridization of the oligonucleotides on the particles with the probe oligonucleotides to produce a satellite probe;

then contacting the satellite probe with the nucleic acid under conditions effective to provide for hybridization of the nucleic acid with the probe oligonucleotides;

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removing the particles; and

detecting the reporter molecule.

92. The method of Claim 91 wherein the particles are magnetic and the reporter molecule is a fluorescent molecule.

93. The method of Claim 91 wherein the particles are magnetic and the reporter molecule is a dye molecule.

94. The method of Claim 91 wherein the particles are magnetic and the reporter molecule is a redox-active molecule.

95. A kit comprising at least one container, the container holding a composition comprising at least two types of nanoparticles having oligonucleotides attached thereto, the oligonucleotides on the first type of nanoparticles having a sequence complementary to the sequence of a first portion of a nucleic acid, the oligonucleotides on the second type of nanoparticles having a sequence complementary to the sequence of a second portion of the nucleic acid.

96. The kit of Claim 95 wherein the composition in the container further comprises a filler oligonucleotide having a sequence complementary to a third portion of the nucleic acid, the third portion being located between the first and second portions.

97. The kit of Claim 95 wherein the nanoparticles are made of gold.

98. The kit of Claim 95 further comprising a solid surface.

99. A kit comprising at least two containers,
the first container holding nanoparticles having oligonucleotides attached thereto which have a sequence complementary to the sequence of a first portion of a nucleic acid, and

the second container holding nanoparticles having oligonucleotides attached thereto which have a sequence complementary to the sequence of a second portion of the nucleic acid.

5 100. The kit of Claim 99 comprising a third container holding oligonucleotides having a sequence complementary to a third portion of the nucleic acid, the third portion being located between the first and second portions.

10 101. The kit of Claim 99 wherein the nanoparticles are made of gold.

102. The kit of Claim 99 further comprising a solid surface.

15 103. A kit comprising at least two containers,
the first container holding nanoparticles having oligonucleotides attached thereto which have a sequence complementary to the sequence of a first portion of a binding oligonucleotide, and

the second container holding one or more types of binding oligonucleotides, each of which has a sequence comprising at least two portions, the first portion being complementary to the sequence of the oligonucleotides on the nanoparticles and the second portion being complementary to the sequence of a portion of a nucleic acid.

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104. The kit of Claim 103 which comprises additional containers, each holding an additional binding oligonucleotide, each additional binding oligonucleotide having a sequence comprising at least two portions, the first portion being complementary to the sequence of the oligonucleotides on the nanoparticles and the second portion being complementary to the sequence of another portion of the nucleic acid.

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105. The kit of Claim 103 wherein the nanoparticles are made of gold.

106. The kit of Claim 103 further comprising a solid surface.

5 107. A kit comprising:

a container holding one type of nanoparticles having oligonucleotides attached thereto and one or more types of binding oligonucleotides, each of the types of binding oligonucleotides having a sequence comprising at least two portions, the first portion being complementary to the sequence of the oligonucleotides on the
10 nanoparticles, whereby the binding oligonucleotides are hybridized to the oligonucleotides on the nanoparticles, and the second portion being complementary to the sequence of one or more portions of a nucleic acid.

108. A kit comprising at least one container, the container holding metallic or
15 semiconductor nanoparticles having oligonucleotides attached thereto, the oligonucleotides having a sequence complementary to a portion of a nucleic acid and having fluorescent molecules attached to the ends of the oligonucleotides not attached to the nanoparticles.

20 109. A kit comprising:

a substrate, the substrate having attached thereto nanoparticles, the nanoparticles having oligonucleotides attached thereto which have a sequence complementary to the sequence of a first portion of a nucleic acid; and

a first container holding nanoparticles having oligonucleotides attached
25 thereto which have a sequence complementary to the sequence of a second portion of the nucleic acid.

110. The kit of Claim 109 further comprising:

a second container holding a binding oligonucleotide having a selected sequence having at least two portions, the first portion being complementary to at least a portion of the sequence of the oligonucleotides on the nanoparticles in the first container; and

5 a third container holding nanoparticles having oligonucleotides attached thereto, the oligonucleotides having a sequence complementary to the sequence of a second portion of the binding oligonucleotide.

111. A kit comprising at least three containers:

10 the first container holding nanoparticles;

the second container holding a first oligonucleotide having a sequence complementary to the sequence of a first portion of a nucleic acid; and

the third container holding a second oligonucleotide having a sequence complementary to the sequence of a second portion of the nucleic acid.

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112. The kit of Claim 111 further comprising a fourth container holding a third oligonucleotide having a sequence complementary to the sequence of a third portion of the nucleic acid, the third portion being located between the first and second portions.

20 113. The kit of Claim 111 further comprising a substrate.

114. The kit of Claim 113 further comprising:

25 a fourth container holding a binding oligonucleotide having a selected sequence having at least two portions, the first portion being complementary to at least a portion of the sequence of the second oligonucleotide; and

a fifth container holding an oligonucleotide having a sequence complementary to the sequence of a second portion of the binding oligonucleotide.

115. The kit of Claim 111 wherein the oligonucleotides, nanoparticles, or both bear functional groups for attachment of the oligonucleotides to the nanoparticles.

116. The kit of Claim 113 wherein the substrate, nanoparticles, or both bear functional groups for attachment of the nanoparticles to the substrate.

117. The kit of Claim 113 wherein the substrate has nanoparticles attached to it.

118. The kit of Claim 111 wherein the nanoparticles are made of gold.

119. A kit comprising:

a substrate having oligonucleotides attached thereto which have a sequence complementary to the sequence of a first portion of a nucleic acid;

a first container holding nanoparticles having oligonucleotides attached thereto, some of which have a sequence complementary to the sequence of a second portion of the nucleic acid; and

a second container holding nanoparticles having oligonucleotides attached thereto which have a sequence complementary to at least a portion of the sequence of the oligonucleotides attached to the nanoparticles in the first container.

120. A kit comprising:

a substrate;

a first container holding nanoparticles;

a second container holding a first oligonucleotide having a sequence complementary to the sequence of a first portion of a nucleic acid;

a third container holding a second oligonucleotide having a sequence complementary to the sequence of a second portion of the nucleic acid; and

a fourth container holding a third oligonucleotide having a sequence

complementary to at least a portion of the sequence of the second oligonucleotide.

121. The kit of Claim 120 wherein the oligonucleotides, nanoparticles, substrate or all bear functional groups for attachment of the oligonucleotides to the nanoparticles or for attachment of the oligonucleotides to the substrate.

122. The kit of Claim 120 wherein the nanoparticles are made of gold.

123. A kit comprising:

10 a substrate having oligonucleotides attached thereto which have a sequence complementary to the sequence of a first portion of a nucleic acid;

a first container holding liposomes having oligonucleotides attached thereto which have a sequence complementary to the sequence of a second portion of the nucleic acid; and

15 a second container holding nanoparticles having at least a first type of oligonucleotides attached thereto, the first type of oligonucleotides having a hydrophobic group attached to the end not attached to the nanoparticles.

124. The kit of Claim 123 wherein:

20 the nanoparticles in the second container have a second type of oligonucleotides attached thereto, the second type of oligonucleotides having a sequence complementary to the sequence of the oligonucleotides on a second type of nanoparticles;

and the kit further comprises:

25 a third container holding a second type of nanoparticles having oligonucleotides attached thereto, the oligonucleotides having a sequence complementary to at least a portion of the sequence of the second type of oligonucleotides on the first type of nanoparticles.

125. A kit comprising:

a substrate, the substrate having attached thereto nanoparticles, the nanoparticles having oligonucleotides attached thereto which have a sequence complementary to the sequence of a first portion of a nucleic acid; and

5 a first container holding an aggregate probe comprising at least two types of nanoparticles having oligonucleotides attached thereto, the nanoparticles of the aggregate probe being bound to each other as a result of the hybridization of some of the oligonucleotides attached to them, at least one of the types of nanoparticles of the aggregate probe having oligonucleotides attached thereto which have a sequence
10 complementary to a second portion of the sequence of the nucleic acid.

126. A kit comprising:

a substrate, the substrate having oligonucleotides attached thereto, the oligonucleotides having a sequence complementary to the sequence of a first portion of a
15 nucleic acid; and

a first container holding an aggregate probe comprising at least two types of nanoparticles having oligonucleotides attached thereto, the nanoparticles of the aggregate probe being bound to each other as a result of the hybridization of some of the oligonucleotides attached to them, at least one of the types of nanoparticles of the
20 aggregate probe having oligonucleotides attached thereto which have a sequence complementary to a second portion of the sequence of the nucleic acid.

127. The kit of Claim 126 wherein the substrate has a plurality of types of oligonucleotides attached to it in an array to allow for the detection of multiple portions
25 of a single nucleic acid, the detection of multiple different nucleic acids, or both.

128. A kit comprising:

a substrate having oligonucleotides attached thereto;

a first container holding an aggregate probe comprising at least two types of nanoparticles having oligonucleotides attached thereto, the nanoparticles of the aggregate probe being bound to each other as a result of the hybridization of some of the oligonucleotides attached to them, at least one of the types of nanoparticles of the aggregate probe having oligonucleotides attached thereto which have a sequence complementary to a first portion of the sequence of the nucleic acid; and

a second container holding nanoparticles having at least two types of oligonucleotides attached thereto, the first type of oligonucleotides having a sequence complementary to a second portion of the sequence of the nucleic acid, and the second type of oligonucleotides having a sequence complementary to at least a portion of the sequence of the oligonucleotides attached to the substrate.

129. A kit comprising:

a substrate, the substrate having oligonucleotides attached thereto, the oligonucleotides having a sequence complementary to the sequence of a first portion of a nucleic acid;

a first container holding liposomes having oligonucleotides attached thereto which have a sequence complementary to the sequence of a second portion of the nucleic acid; and

a second container holding an aggregate probe comprising at least two types of nanoparticles having oligonucleotides attached thereto, the nanoparticles of the aggregate probe being bound to each other as a result of the hybridization of some of the oligonucleotides attached to them, at least one of the types of nanoparticles of the aggregate probe having oligonucleotides attached thereto which have a hydrophobic group attached to the end not attached to the nanoparticles.

130. The kit of any one of Claims 125-129 wherein the substrate is a transparent substrate or an opaque white substrate.

131. The kit of any one of Claims 125-129 wherein the nanoparticles of the aggregate probe are made of gold.

5 132. A kit comprising at least three containers:
 the first container holding nanoparticles;
 the second container holding a first oligonucleotide having a sequence
complementary to the sequence of a first portion of a nucleic acid; and
 the third container holding a second oligonucleotide having a sequence
10 complementary to the sequence of a second portion of the nucleic acid.

133. The kit of Claim 132 further comprising a fourth container holding a third
oligonucleotide having a sequence complementary to the sequence of a third portion of
the nucleic acid, the third portion being located between the first and second portions.

15

134. The kit of Claim 132 further comprising a substrate.

135. The kit of Claim 134 further comprising:
 a fourth container holding a binding oligonucleotide having a selected
20 sequence having at least two portions, the first portion being complementary to at least a
portion of the sequence of the second oligonucleotide; and
 a fifth container holding an oligonucleotide having a sequence
complementary to the sequence of a second portion of the binding oligonucleotide.

25 136. The kit of Claim 132 wherein the oligonucleotides, nanoparticles, or both
bear functional groups for attachment of the oligonucleotides to the nanoparticles.

137. The kit of Claim 134 wherein the substrate, nanoparticles, or both bear

functional groups for attachment of the nanoparticles to the substrate.

138. The kit of Claim 134 wherein the substrate has nanoparticles attached to it.

5 139. The kit of Claim 132 wherein the nanoparticles are made of gold.

140. A kit comprising:

a substrate having oligonucleotides attached thereto which have a sequence complementary to the sequence of a first portion of a nucleic acid;

10 a first container holding nanoparticles having oligonucleotides attached thereto, some of which have a sequence complementary to the sequence of a second portion of the nucleic acid; and

a second container holding nanoparticles having oligonucleotides attached thereto which have a sequence complementary to at least a portion of the sequence of the
15 oligonucleotides attached to the nanoparticles in the first container.

141. A kit comprising:

a substrate;

a first container holding nanoparticles;

20 a second container holding a first oligonucleotide having a sequence complementary to the sequence of a first portion of a nucleic acid;

a third container holding a second oligonucleotide having a sequence complementary to the sequence of a second portion of the nucleic acid; and

25 a fourth container holding a third oligonucleotide having a sequence complementary to at least a portion of the sequence of the second oligonucleotide.

142. The kit of Claim 141 wherein the oligonucleotides, nanoparticles, substrate or all bear functional groups for attachment of the oligonucleotides to the

nanoparticles or for attachment of the oligonucleotides to the substrate.

143. The kit of Claim 141 wherein the nanoparticles are made of gold.

5 144. A kit comprising:

a substrate having oligonucleotides attached thereto which have a sequence complementary to the sequence of a first portion of a nucleic acid;

a first container holding liposomes having oligonucleotides attached thereto which have a sequence complementary to the sequence of a second portion of the
10 nucleic acid; and

a second container holding nanoparticles having at least a first type of oligonucleotides attached thereto, the first type of oligonucleotides having a hydrophobic group attached to the end not attached to the nanoparticles.

15 145. The kit of Claim 144 wherein:

the nanoparticles in the second container have a second type of oligonucleotides attached thereto, the second type of oligonucleotides having a sequence complementary to the sequence of the oligonucleotides on a second type of nanoparticles;
and the kit further comprises:

20 a third container holding a second type of nanoparticles having oligonucleotides attached thereto, the oligonucleotides having a sequence complementary to at least a portion of the sequence of the second type of oligonucleotides on the first type of nanoparticles.

25 146. A kit comprising at least two containers,

the first container holding particles having oligonucleotides attached thereto which have a sequence complementary to the sequence of a first portion of a nucleic acid, the oligonucleotides being labeled with an energy donor on the ends not

attached to the particles,

the second container holding particles having oligonucleotides attached thereto which have a sequence complementary to the sequence of a second portion of a nucleic acid, the oligonucleotides being labeled with an energy acceptor on the ends not
5 attached to the particles.

147. The kit of Claim 146 wherein the energy donor and acceptor are fluorescent molecules.

10 148. A kit comprising at least one container, the container holding a first type of particles having oligonucleotides attached thereto which have a sequence complementary to the sequence of a first portion of a nucleic acid, the oligonucleotides being labeled with an energy donor on the ends not attached to the particles, and a second
15 type of particles having oligonucleotides attached thereto which have a sequence complementary to the sequence of a second portion of a nucleic acid, the oligonucleotides being labeled with an energy acceptor on the ends not attached to the particles.

149. The kit of Claim 148 wherein the energy donor and acceptor are fluorescent molecules.

20

150. A kit comprising:

a first container holding a type of microspheres having oligonucleotides attached thereto, the oligonucleotides having a sequence complementary to a first portion of the sequence of a nucleic acid and being labeled with a fluorescent molecule; and

25 a second container holding a type of nanoparticles having oligonucleotides attached thereto, the oligonucleotides having a sequence complementary to a second portion of the sequence of the nucleic acid.

151. The kit of Claim 150 wherein the microspheres are latex microspheres and the nanoparticles are gold nanoparticles.

152. The kit of Claim 150 further comprising a microporous material.

5

153. A kit comprising:

a first container holding a first type of metallic or semiconductor nanoparticles having oligonucleotides attached thereto, the oligonucleotides having a sequence complementary to a first portion of the sequence of a nucleic acid and being labeled with a fluorescent molecule; and

10

a second container holding a second type of metallic or semiconductor nanoparticles having oligonucleotides attached thereto, the oligonucleotides having a sequence complementary to a second portion of the sequence of a nucleic acid and being labeled with a fluorescent molecule.

15

154. The kit of Claim 153 further comprising a microporous material.

155. A kit comprising a container holding a satellite probe, the satellite probe comprising:

20

a particle having attached thereto oligonucleotides, the oligonucleotides having a first portion and a second portion, both portions having sequences complementary to portions of the sequence of a nucleic acid; and

25

probe oligonucleotides hybridized to the oligonucleotides attached to the nanoparticles, the probe oligonucleotides having a first portion and a second portion, the first portion having a sequence complementary to the sequence of the first portion of the oligonucleotides attached to the particles, both portions having sequences complementary to portions of the sequence of the nucleic acid, the probe oligonucleotides further having a reporter molecule attached to one end.

156. A kit comprising a container holding an aggregate probe, the aggregate probe comprising at least two types of nanoparticles having oligonucleotides attached thereto, the nanoparticles of the aggregate probe being bound to each other as a result of the hybridization of some of the oligonucleotides attached to them, at least one of the types of nanoparticles of the aggregate probe having oligonucleotides attached thereto which have a sequence complementary to a portion of the sequence of a nucleic acid.

157. A kit comprising a container holding an aggregate probe, the aggregate probe comprising at least two types of nanoparticles having oligonucleotides attached thereto, the nanoparticles of the aggregate probe being bound to each other as a result of the hybridization of some of the oligonucleotides attached to them, at least one of the types of nanoparticles of the aggregate probe having oligonucleotides attached thereto which have a hydrophobic group attached to the end not attached to the nanoparticles.

158. An aggregate probe, the aggregate probe comprising at least two types of nanoparticles having oligonucleotides attached thereto, the nanoparticles of the aggregate probe being bound to each other as a result of the hybridization of some of the oligonucleotides attached to them, at least one of the types of nanoparticles of the aggregate probe having oligonucleotides attached thereto which have a sequence complementary to a portion of the sequence of a nucleic acid.

159. The aggregate probe of Claim 158 comprising two types of nanoparticles each having two types of oligonucleotides attached thereto, the first type of oligonucleotides attached to each type of nanoparticles having a sequence complementary to a portion of the sequence of a nucleic acid, the second type of oligonucleotides attached to the first type of nanoparticles having a sequence complementary to at least a portion of the sequence of the second type of oligonucleotides attached to the second type

of nanoparticles.

160. The aggregate probe of Claim 158 comprising three types of nanoparticles having oligonucleotides attached thereto, the oligonucleotides attached to the first type of nanoparticles having a sequence complementary to at least a portion of the sequence of the oligonucleotides attached to the second type of nanoparticles, the oligonucleotides attached to the second type of nanoparticles having a sequence complementary to at least a portion of the sequence of the oligonucleotides attached to the first type of nanoparticles, and the third type of nanoparticles having two types of oligonucleotides attached thereto, the first type of oligonucleotides having a sequence complementary to a portion of the sequence of a nucleic acid, and the second type of oligonucleotides having a sequence complementary to at least a portion of the sequence of the oligonucleotides attached to the first or second type of nanoparticles.

161. An aggregate probe, the aggregate probe comprising at least two types of nanoparticles having oligonucleotides attached thereto, the nanoparticles of the aggregate probe being bound to each other as a result of the hybridization of some of the oligonucleotides attached to them, at least one of the types of nanoparticles of the aggregate probe having oligonucleotides attached thereto which have a hydrophobic group attached to the end not attached to the nanoparticles.

162. A kit comprising a container holding a core probe, the core probe comprising at least two types of nanoparticles having oligonucleotides attached thereto, the nanoparticles of the core probe being bound to each other as a result of the hybridization of some of the oligonucleotides attached to them.

163. The kit of Claim 162 further comprising a substrate having oligonucleotides attached thereto, the oligonucleotides having a sequence complementary to a first portion

of the sequence of a nucleic acid to be detected.

164. The kit of Claim 162 or 163 further comprising a container holding a type of nanoparticles having two types of oligonucleotides attached thereto, the first type of
5 oligonucleotides having a sequence complementary to a second portion of the nucleic acid, and the second type of oligonucleotides having sequence complementary to a portion of the sequence of the oligonucleotides attached to at least one of the types of nanoparticles of the core probe.

10 165. The kit of Claim 162 or 163 further comprising a container holding a type of linking oligonucleotides comprising a sequence complementary to a second portion of the sequence of the nucleic acid and a sequence complementary to a portion of the sequence of the oligonucleotides attached to at least one of the types of nanoparticles of the core probe.

15 166. A core probe comprising at least two types of nanoparticles having oligonucleotides attached thereto, the nanoparticles of the core probe being bound to each other as a result of the hybridization of some of the oligonucleotides attached to them.

20 167. A substrate having nanoparticles attached thereto.

168. The substrate of Claim 167 wherein the nanoparticles have oligonucleotides attached thereto which have a sequence complementary to the sequence of a first portion of a nucleic acid.

25 169. A metallic or semiconductor nanoparticle having oligonucleotides attached thereto, the oligonucleotides being labeled with fluorescent molecules at the ends not attached to the nanoparticle.

170. A satellite probe comprising:

a particle having attached thereto oligonucleotides, the oligonucleotides having a first portion and a second portion, both portions having sequences complementary to portions of the sequence of a nucleic acid; and

probe oligonucleotides hybridized to the oligonucleotides attached to the nanoparticles, the probe oligonucleotides having a first portion and a second portion, the first portion having a sequence complementary to the sequence of the first portion of the oligonucleotides attached to the particles, both portions having sequences complementary to portions of the sequence of the nucleic acid, the probe oligonucleotides further having a reporter molecule attached to one end.

171. A method of nanofabrication comprising

providing at least one type of linking oligonucleotide having a selected sequence, the sequence of each type of linking oligonucleotide having at least two portions;

providing one or more types of nanoparticles having oligonucleotides attached thereto, the oligonucleotides on each of the types of nanoparticles having a sequence complementary to the sequence of a portion of a linking oligonucleotide; and

contacting the linking oligonucleotides and nanoparticles under conditions effective to allow hybridization of the oligonucleotides on the nanoparticles to the linking oligonucleotides so that a desired nanomaterial or nanostructure is formed wherein the nanoparticles are held together by oligonucleotide connectors.

172. The method of Claim 171 wherein at least two types of nanoparticles having oligonucleotides attached thereto are provided, the oligonucleotides on the first type of nanoparticles having a sequence complementary to a first portion of the sequence of a linking oligonucleotide, and the oligonucleotides on the second type of nanoparticles

having a sequence complementary to a second portion of the sequence of the linking oligonucleotide.

173. The method of Claim 171 or 172 wherein the nanoparticles are metallic nanoparticles, semiconductor nanoparticles, or a combination thereof.

174. The method of Claim 173 wherein the metallic nanoparticles are made of gold, and the semiconductor nanoparticles are made of CdSe/ZnS (core/shell).

175. A method of nanofabrication comprising:
providing at least two types of nanoparticles having oligonucleotides attached thereto,
the oligonucleotides on the first type of nanoparticles having a sequence complementary to that of the oligonucleotides on the second of the nanoparticles;
the oligonucleotides on the second type of nanoparticles having a sequence complementary to that of the oligonucleotides on the first type of nanoparticles;
and
contacting the first and second types of nanoparticles under conditions effective to allow hybridization of the oligonucleotides on the nanoparticles to each other so that a desired nanomaterial or nanostructure is formed.

176. The method of Claim 175 wherein the nanoparticles are metallic nanoparticles, semiconductor nanoparticles, or a combination thereof.

177. The method of Claim 176 wherein the metallic nanoparticles are made of gold, and the semiconductor nanoparticles are made of CdSe/ZnS (core/shell).

178. Nanomaterials or nanostructures composed of nanoparticles having

oligonucleotides attached thereto, the nanoparticles being held together by oligonucleotide connectors.

179. The nanomaterials or nanostructures of Claim 178 wherein at least some of
5 the oligonucleotide connectors are triple-stranded.

180. The nanomaterials or nanostructures of Claim 178 wherein the nanoparticles are metallic nanoparticles, semiconductor nanoparticles, or a combination thereof.

10

181. The nanomaterials or nanostructures of Claim 180 wherein the metallic nanoparticles are made of gold, and the semiconductor nanoparticles are made of CdSe/ZnS (core/shell).

15 182. A composition comprising at least two types of nanoparticles having oligonucleotides attached thereto, the oligonucleotides on the first type of nanoparticles having a sequence complementary to the sequence of a first portion of a nucleic acid or a linking oligonucleotide, the oligonucleotides on the second type of nanoparticles having a sequence complementary to the sequence of a second portion of the nucleic acid or
20 linking oligonucleotide.

183. The composition of Claim 182 wherein the nanoparticles are metallic nanoparticles, semiconductor nanoparticles, or a combination thereof.

25 184. The composition of Claim 183 wherein the metallic nanoparticles are made of gold, and the semiconductor nanoparticles are made of CdSe/ZnS (core/shell).

185. An assembly of containers comprising:

a first container holding nanoparticles having oligonucleotides attached thereto, and

a second container holding nanoparticles having oligonucleotides attached thereto,

5 the oligonucleotides attached to the nanoparticles in the first container having a sequence complementary to that of the oligonucleotides attached to the nanoparticles in the second container,

the oligonucleotides attached to the nanoparticles in the second container having a sequence complementary to that of the oligonucleotides attached to the
10 nanoparticles in the second container.

186. The assembly of Claim 185 wherein the nanoparticles are metallic nanoparticles, semiconductor nanoparticles, or a combination thereof.

15 187. The assembly of Claim 186 wherein the metallic nanoparticles are made of gold, and the semiconductor nanoparticles are made of CdSe/ZnS (core/shell).

188. A nanoparticle having a plurality of different oligonucleotides attached thereto.

20

189. A method of separating a selected nucleic acid having at least two portions from other nucleic acids, the method comprising:

providing two or more types of nanoparticles having oligonucleotides attached thereto, the oligonucleotides on each of the types of nanoparticles having a
25 sequence complementary to the sequence of one of the portions of the selected nucleic acid; and

contacting the nucleic acids and nanoparticles under conditions effective to allow hybridization of the oligonucleotides on the nanoparticles with the selected

nucleic acid so that the nanoparticles hybridized to the selected nucleic acid aggregate and precipitate.

190. A method of binding oligonucleotides to charged nanoparticles to produce
5 stable nanoparticle-oligonucleotide conjugates, the method comprising:

providing oligonucleotides having covalently bound thereto a moiety
comprising a functional group which can bind to the nanoparticles;

contacting the oligonucleotides and the nanoparticles in water for a period
of time sufficient to allow at least some of the oligonucleotides to bind to the
10 nanoparticles;

adding at least one salt to the water to form a salt solution, the ionic
strength of the salt solution being sufficient to overcome at least partially the electrostatic
attraction or repulsion of the oligonucleotides for the nanoparticles and the electrostatic
repulsion of the oligonucleotides for each other; and

15 contacting the oligonucleotides and nanoparticles in the salt solution for an
additional period of time sufficient to allow sufficient additional oligonucleotides to bind
to the nanoparticles to produce the stable nanoparticle-oligonucleotide conjugates.

191. The method of Claim 190 wherein the nanoparticles are metal
20 nanoparticles or semiconductor nanoparticles.

192. The method of Claim 191 wherein the nanoparticles are gold
nanoparticles.

25 193. The method of Claim 192 wherein the moiety comprising a functional
group which can bind to the nanoparticles is an alkanethiol.

194. The method of Claim 190 wherein all of the salt is added to the water in a

single addition.

195. The method of Claim 190 wherein the salt is added gradually over time.

5 196. The method of Claim 190 wherein the salt is selected from the group consisting of sodium chloride, magnesium chloride, potassium chloride, ammonium, chloride, sodium, acetate, ammonium acetate, a combination of two or more of these salts, one of these salts in a phosphate buffer, and a combination of two or more these salts in a phosphate buffer.

10

197. The method of Claim 196 wherein the salt is sodium chloride in a phosphate buffer.

15 198. The method of Claim 190 wherein nanoparticle-oligonucleotide conjugates are produced which have the oligonucleotides present on surface of the nanoparticles at a surface density of at least 10 picomoles/cm².

199. The method of Claim 198 wherein the oligonucleotides are present on surface of the nanoparticles at a surface density of at least 15 picomoles/cm².

20

200. The method of Claim 199 wherein the oligonucleotides are present on surface of the nanoparticles at a surface density of from about 15 picomoles/cm² to about 40 picomoles/cm².

25 201. A method of binding oligonucleotides to nanoparticles to produce nanoparticle-oligonucleotide conjugates, the method comprising:

providing oligonucleotides, the oligonucleotides comprising at least one type of recognition oligonucleotides, each of the recognition oligonucleotides comprising

a spacer portion and a recognition portion, the spacer portion being designed so that it can bind to the nanoparticles; and

5 contacting the oligonucleotides and the nanoparticles under conditions effective to allow at least some of the recognition oligonucleotides to bind to the nanoparticles to produce the nanoparticle-oligonucleotide conjugates.

10 202. The method of Claim 201 wherein each of the spacer portions of the recognition oligonucleotides has a moiety covalently bound thereto, the moiety comprising a functional group which can bind to the nanoparticles.

 203. The method of Claim 201 wherein the nanoparticles are metal nanoparticles or semiconductor nanoparticles.

15 204. The method of Claim 203 wherein the nanoparticles are gold nanoparticles.

 205. The method of Claim 204 wherein the spacer portion comprises at least about 10 nucleotides.

20 206. The method of Claim 205 wherein the spacer portion comprises from about 10 to about 30 nucleotides.

 207. The method of Claim 206 wherein the bases of the nucleotides of the spacer are all adenines, all thymines, all cytosines, all uracils, or all guanines.

25 208. A method of binding oligonucleotides to nanoparticles to produce nanoparticle-oligonucleotide conjugates, the method comprising:

 providing oligonucleotides, the oligonucleotides comprising:

a type of recognition oligonucleotides; and
a type of diluent oligonucleotides;
contacting the oligonucleotides with the nanoparticles under conditions
effective to allow at least some of each of the types of oligonucleotides to bind to the
5 nanoparticles to produce the nanoparticle-oligonucleotide conjugates.

209. The method of Claim 208 wherein the nanoparticles are metal
nanoparticles or semiconductor nanoparticles.

10 210. The method of Claim 209 wherein the nanoparticles are gold
nanoparticles.

211. The method of Claim 208 wherein each of the recognition
oligonucleotides comprises a spacer portion and a recognition portion, the spacer portion
15 being designed so that it can bind to the nanoparticles.

212. The method of Claim 211 wherein each of the spacer portions of the
recognition oligonucleotides has a moiety covalently bound thereto, the moiety
comprising a functional group which can bind to the nanoparticles.

20 213. The method of Claim 211 wherein the spacer portions of the recognition
oligonucleotides comprises at least about 10 nucleotides.

214. The method of Claim 213 wherein the spacer portions of the recognition
25 oligonucleotides comprises from about 10 nucleotides to about 30 nucleotides.

215. The method of Claim 211 wherein the bases of the nucleotides of the
spacer are all adenines, all thymines, all cytosines, all uracils or all guanines.

216. The method of Claim 211 wherein the diluent oligonucleotides contain about the same number of nucleotides as are contained in the spacer portions of the recognition oligonucleotides.

5

217. The method of Claim 216 wherein the sequence of the diluent oligonucleotides is the same as the sequence of the spacer portions of the recognition oligonucleotides.

10

218. The method of Claim 208 wherein the oligonucleotides comprise at least two types of recognition oligonucleotides.

219. A method of binding oligonucleotides to charged nanoparticles to produce nanoparticle-oligonucleotide conjugates, the method comprising:

15

providing oligonucleotides having covalently bound thereto a moiety comprising a functional group which can bind to the nanoparticles, the oligonucleotides comprising:

a type of recognition oligonucleotides; and

a type of diluent oligonucleotides;

20

contacting the oligonucleotides with the nanoparticles in water for a period of time sufficient to allow at least some of each of the types of oligonucleotides to bind to the nanoparticles;

adding at least one salt to the water to form a salt solution, the ionic strength of the salt solution being sufficient to overcome at least partially the electrostatic attraction or repulsion of the oligonucleotides for the nanoparticles and the electrostatic repulsion of the oligonucleotides for each other; and

25

contacting the oligonucleotides and nanoparticles in the salt solution for an additional period of time sufficient to allow additional oligonucleotides of each of the

types of oligonucleotides to bind to the nanoparticles to produce the nanoparticle-oligonucleotide conjugates.

220. The method of Claim 219 wherein the nanoparticles are metal
5 nanoparticles or semiconductor nanoparticles.

221. The method of Claim 220 wherein the nanoparticles are gold nanoparticles.

10 222. The method of Claim 221 wherein the moiety comprising a functional group which can bind to the nanoparticles is an alkanethiol.

223. The method of Claim 219 wherein all of the salt is added to the water in a single addition.

15

224. The method of Claim 219 wherein the salt is added gradually over time.

225. The method of Claim 219 wherein the salt is selected from the group consisting of sodium chloride, magnesium chloride, potassium chloride, ammonium, chloride, sodium, acetate, ammonium acetate, a combination of two or more of these
20 salts, one of these salts in a phosphate buffer, and a combination of two or more these salts in a phosphate buffer.

226. The method of Claim 225 wherein the salt is sodium chloride in a
25 phosphate buffer.

227. The method of Claim 219 wherein nanoparticle-oligonucleotide conjugates are produced which have the oligonucleotides are present on surface of the

nanoparticles at a surface density of at least 10 picomoles/cm².

228. The method of Claim 227 wherein the oligonucleotides are present on surface of the nanoparticles at a surface density of at least 15 picomoles/cm².

5

229. The method of Claim 228 wherein the oligonucleotides are present on surface of the nanoparticles at a surface density of from about 15 picomoles/cm² to about 40 picomoles/cm².

10 230. The method of Claim 219 wherein each of the recognition oligonucleotides comprises a spacer portion and a recognition portion, the spacer portion having attached to it the moiety comprising a functional group which can bind to the nanoparticles.

15 231. The method of Claim 230 wherein the spacer portion comprises at least about 10 nucleotides.

232. The method of Claim 231 wherein the spacer portion comprises from about 10 to about 30 nucleotides.

20

233. The method of Claim 230 wherein the bases of the nucleotides of the spacers are all adenines, all thymines, all cytosines, all uracils, or all guanines.

234. The method of Claim 230 wherein the diluent oligonucleotides contain about the same number of nucleotides as are contained in the spacer portions of the recognition oligonucleotides.

25

235. The method of Claim 234 wherein the sequence of the diluent

oligonucleotides is the same as the sequence of the spacer portions of the recognition oligonucleotides.

236. The method of Claim 219 wherein the oligonucleotides comprise at least
5 two types of recognition oligonucleotides.

237. Nanoparticle-oligonucleotide conjugates which are nanoparticles having
oligonucleotides attached to them, the oligonucleotides being present on surface of the
nanoparticles at a surface density sufficient so that the conjugates are stable, at least some
10 of the oligonucleotides having a sequence complementary to at least one portion of the
sequence of a nucleic acid or another oligonucleotide..

238. The conjugates of Claim 237 wherein the oligonucleotides are present on
surface of the nanoparticles at a surface density of at least 10 picomoles/cm²
15

239. The nanoparticles of Claim 238 wherein the oligonucleotides are present
on surface of the nanoparticles at a surface density of at least 15 picomoles/cm².

240. The nanoparticles of Claim 239 wherein the oligonucleotides are present
20 on surface of the nanoparticles at a surface density of from about 15 picomoles/cm² to
about 40 picomoles/cm².

241. The nanoparticles of Claim 237 wherein the nanoparticles are metal
nanoparticles or semiconductor nanoparticles.
25

242. The nanoparticles of Claim 241 wherein the nanoparticles are gold
nanoparticles.

243. Nanoparticles having oligonucleotides attached to them, the oligonucleotides comprising at least one type of recognition oligonucleotides, each of the recognition oligonucleotides comprising a spacer portion and a recognition portion, the spacer portion being designed so that it is bound to the nanoparticles, the recognition
5 portion having a sequence complementary to at least one portion of the sequence of a nucleic acid or another oligonucleotide.

244. The nanoparticles of Claim 243 wherein the spacer portion has a moiety covalently bound to it, the moiety comprising a functional group through which the
10 spacer portion is bound to the nanoparticles.

245. The nanoparticles of Claim 243 wherein the spacer portion comprises at least about 10 nucleotides.

15 246. The nanoparticles of Claim 245 wherein the spacer portion comprises from about 10 to about 30 nucleotides.

247. The nanoparticles of Claim 243 wherein the bases of the nucleotides of the spacer portion are all adenines, all thymines, all cytosines, all uracils or all guanines.
20

248. The nanoparticles of Claim 243 wherein the oligonucleotides are present on surface of the nanoparticles at a surface density of at least 10 picomoles/cm².

249. The nanoparticles of Claim 248 wherein the oligonucleotides are present
25 on surface of the nanoparticles at a surface density of at least 15 picomoles/cm².

250. The nanoparticles of Claim 249 wherein the oligonucleotides are present on surface of the nanoparticles at a surface density of from about 15 picomoles/cm² to

about 40 picomoles/cm².

251. The nanoparticles of Claim 243 wherein the nanoparticles are metal nanoparticles or semiconductor nanoparticles.

5

252. The method of Claim 251 wherein the nanoparticles are gold nanoparticles.

253. Nanoparticles having oligonucleotides attached to them, the
10 oligonucleotides comprising:

at least one type of recognition oligonucleotides, each of the types of recognition oligonucleotides comprising a sequence complementary to at least one portion of the sequence of a nucleic acid or another oligonucleotide; and

a type of diluent oligonucleotides.

15

254. The nanoparticles of Claim 253 wherein, each of the recognition oligonucleotides comprises a spacer portion and a recognition portion, the spacer portion being designed so that it is bound to the nanoparticles, the recognition portion having a sequence complementary to at least one portion of the sequence of a nucleic acid or
20 another oligonucleotide.

255. The nanoparticles of Claim 254 wherein the spacer portion has a moiety covalently bound to it, the moiety comprising a functional group through which the spacer portion is bound to the nanoparticles.

25

256. The nanoparticles of Claim 254 wherein the spacer portion comprises at least about 10 nucleotides.

257. The nanoparticles of Claim 256 wherein the spacer portion comprises from about 10 to about 30 nucleotides.

258. The nanoparticles of Claim 254 wherein the bases of the nucleotides of the spacer portion are all adenines, all thymines, all cytosines, all uracils or all guanines.

259. The nanoparticles of Claim 253 wherein the oligonucleotides are present on surface of the nanoparticles at a surface density of at least 10 picomoles/cm².

260. The nanoparticles of Claim 259 wherein the oligonucleotides are present on surface of the nanoparticles at a surface density of at least 15 picomoles/cm².

261. The nanoparticles of Claim 260 wherein the oligonucleotides are present on surface of the nanoparticles at a surface density of from about 15 picomoles/cm² to about 40 picomoles/cm².

262. The nanoparticles of Claim 254 wherein the diluent oligonucleotides contain about the same number of nucleotides as are contained in the spacer portions of the recognition oligonucleotides.

263. The nanoparticles of Claim 262 wherein the sequence of the diluent oligonucleotides is the same as that of the spacer portions of the recognition oligonucleotides.

264. The nanoparticles of Claim 253 wherein the nanoparticles are metal nanoparticles or semiconductor nanoparticles.

265. The nanoparticles of Claim 264 wherein the nanoparticles are gold nanoparticles.

266. A method of detecting a nucleic acid comprising:

contacting the nucleic acid with at least one type of nanoparticle-oligonucleotide
conjugates according to any one of Claims 237-242 under conditions effective to allow
5 hybridization of the oligonucleotides on the nanoparticles with the nucleic acid; and
observing a detectable change brought about by hybridization of the
oligonucleotides on the nanoparticles with the nucleic acid.

267. A method of detecting a nucleic acid comprising:

10 contacting the nucleic acid with at least one type of nanoparticles according to
any one of Claims 243-265 under conditions effective to allow hybridization of at least
one of the types of recognition oligonucleotides on the nanoparticles with the nucleic
acid; and
observing a detectable change brought about by hybridization of the recognition
15 oligonucleotides with the nucleic acid.

268. A method of detecting a nucleic acid having at least two portions
comprising:

20 providing a type of nanoparticle-oligonucleotide conjugates according to
any one of Claims 237-242, the oligonucleotides on each nanoparticle having a sequence
complementary to the sequence of at least two portions of the nucleic acid;

contacting the nucleic acid and the conjugates under conditions effective
to allow hybridization of the oligonucleotides on the nanoparticles with the two or more
portions of the nucleic acid; and

25 observing a detectable change brought about by hybridization of the
oligonucleotides on the nanoparticles with the nucleic acid.

269. A method of detecting a nucleic acid having at least two portions

comprising:

contacting the nucleic acid with at least two types of nanoparticle-oligonucleotide conjugates according to any one of Claims 237-240, the oligonucleotides on the nanoparticles of the first type of conjugates having a sequence complementary to a first portion of the sequence of the nucleic acid, the oligonucleotides on the nanoparticles of the second type of conjugates having a sequence complementary to a second portion of the sequence of the nucleic acid, the contacting taking place under conditions effective to allow hybridization of the oligonucleotides on the nanoparticles with the nucleic acid; and

observing a detectable change brought about by hybridization of the oligonucleotides on the nanoparticles with the nucleic acid.

270. The method of Claim 269 wherein the contacting conditions include freezing and thawing.

271. The method of Claim 269 wherein the contacting conditions include heating.

272. The method of Claim 269 wherein the detectable change is observed on a solid surface.

273. The method of Claim 269 wherein the detectable change is a color change observable with the naked eye.

274. The method of Claim 273 wherein the color change is observed on a solid surface.

275. The method of Claim 269 wherein the nanoparticles are metal

nanoparticles or semiconductor nanoparticles.

276. The method of Claim 269 wherein the nanoparticles are gold nanoparticles.

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277. The method of Claim 269 wherein the oligonucleotides attached to the nanoparticles are labeled on their ends not attached to the nanoparticles with molecules that produce a detectable change upon hybridization of the oligonucleotides on the nanoparticles with the nucleic acid.

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278. The method of Claim 277 wherein the nanoparticles are metallic or semiconductor nanoparticles and the oligonucleotides attached to the nanoparticles are labeled with fluorescent molecules.

15

279. The method of Claim 269 wherein:

the nucleic acid has a third portion located between the first and second portions, and the sequences of the oligonucleotides on the nanoparticles do not include sequences complementary to this third portion of the nucleic acid; and

20

the nucleic acid is further contacted with a filler oligonucleotide having a sequence complementary to this third portion of the nucleic acid, the contacting taking place under conditions effective to allow hybridization of the filler oligonucleotide with the nucleic acid.

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280. The method of Claim 269 wherein the nucleic acid is viral RNA or DNA.

281. The method of Claim 269 wherein the nucleic acid is a gene associated with a disease.

282. The method of Claim 269 wherein the nucleic acid is a bacterial DNA.
283. The method of Claim 269 wherein the nucleic acid is a fungal DNA.
- 5 284. The method of Claim 269 wherein the nucleic acid is a synthetic DNA, a synthetic RNA, a structurally-modified natural or synthetic RNA, or a structurally-modified natural or synthetic DNA.
- 10 285. The method of Claim 269 wherein the nucleic acid is from a biological source.
286. The method of Claim 269 wherein the nucleic acid is a product of a polymerase chain reaction amplification.
- 15 287. The method of Claim 269 wherein the nucleic acid is contacted with the first and second types of conjugates simultaneously.
- 20 288. The method of Claim 269 wherein the nucleic acid is contacted and hybridized with the oligonucleotides on the nanoparticles of first type of conjugates before being contacted with the second type of conjugates.
289. The method of Claim 288 wherein the first type of conjugates is attached to a substrate.
- 25 290. The method of Claim 269 wherein the nucleic acid is double-stranded and hybridization with the oligonucleotides on the nanoparticles results in the production of a triple-stranded complex.

291. A method of detecting a nucleic acid having at least two portions comprising:

providing a type of nanoparticles according to any one of Claims 243-252 having recognition oligonucleotides attached thereto, the recognition oligonucleotides on
5 each nanoparticle comprising a sequence complementary to the sequence of at least two portions of the nucleic acid;

contacting the nucleic acid and the nanoparticles under conditions effective to allow hybridization of the oligonucleotides on the nanoparticles with the two or more portions of the nucleic acid; and

10 observing a detectable change brought about by hybridization of the oligonucleotides on the nanoparticles with the nucleic acid.

292. A method of detecting nucleic acid having at least two portions comprising:

15 contacting the nucleic acid with at least two types of nanoparticles according to any one of Claims 243-250 having recognition oligonucleotides attached thereto, the recognition oligonucleotides on the first type of nanoparticles comprising a sequence complementary to a first portion of the sequence of the nucleic acid, the recognition oligonucleotides on the second type of nanoparticles comprising a sequence
20 complementary to a second portion of the sequence of the nucleic acid, the contacting taking place under conditions effective to allow hybridization of the recognition oligonucleotides on the nanoparticles with the nucleic acid; and

observing a detectable change brought about by hybridization of the recognition oligonucleotides on the nanoparticles with the nucleic acid.

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293. The method of Claim 292 wherein the contacting conditions include freezing and thawing.

294. The method of Claim 292 wherein the contacting conditions include heating.

295. The method of Claim 292 wherein the detectable change is observed on a
5 solid surface.

296. The method of Claim 292 wherein the detectable change is a color change observable with the naked eye.

10 297. The method of Claim 296 wherein the color change is observed on a solid surface.

298. The method of Claim 292 wherein the nanoparticles are metal nanoparticles or semiconductor nanoparticles.

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299. The method of Claim 298 wherein the nanoparticles are made of gold.

300. The method of Claim 292 wherein the recognition oligonucleotides attached to the nanoparticles are labeled on their ends not attached to the nanoparticles
20 with molecules that produce a detectable change upon hybridization of the oligonucleotides on the nanoparticles with the nucleic acid.

301. The method of Claim 300 wherein the nanoparticles are metallic or semiconductor nanoparticles and the oligonucleotides attached to the nanoparticles are
25 labeled with fluorescent molecules.

302. The method of Claim 292 wherein:
the nucleic acid has a third portion located between the first and second

portions, and the sequences of the oligonucleotides on the nanoparticles do not include sequences complementary to this third portion of the nucleic acid; and

the nucleic acid is further contacted with a filler oligonucleotide having a sequence complementary to this third portion of the nucleic acid, the contacting taking
5 place under conditions effective to allow hybridization of the filler oligonucleotide with the nucleic acid.

303. The method of Claim 292 wherein the nucleic acid is viral RNA or DNA.

10 304. The method of Claim 292 wherein the nucleic acid is a gene associated with a disease.

305. The method of Claim 292 wherein the nucleic acid is a bacterial DNA.

15 306. The method of Claim 292 wherein the nucleic acid is a fungal DNA.

307. The method of Claim 292 wherein the nucleic acid is a synthetic DNA, a synthetic RNA, a structurally-modified natural or synthetic RNA, or a structurally-modified natural or synthetic DNA.

20 308. The method of Claim 292 wherein the nucleic acid is from a biological source.

309. The method of Claim 292 wherein the nucleic acid is a product of a
25 polymerase chain reaction amplification.

310. The method of Claim 292 wherein the nucleic acid is contacted with the first and second types of nanoparticles simultaneously.

311. The method of Claim 292 wherein the nucleic acid is contacted and hybridized with the oligonucleotides on the first type of nanoparticles before being contacted with the second type of nanoparticles.

5

312. The method of Claim 311 wherein the first type of nanoparticles is attached to a substrate.

313. The method of Claim 292 wherein the nucleic acid is double-stranded and hybridization with the oligonucleotides on the nanoparticles results in the production of a triple-stranded complex.

314. A method of detecting a nucleic acid having at least two portions comprising:

15 providing a type of nanoparticles according to any one of Claims 253-265 having recognition oligonucleotides attached thereto, the recognition oligonucleotides on each nanoparticle comprising a sequence complementary to the sequence of at least two portions of the nucleic acid;

20 contacting the nucleic acid and the nanoparticles under conditions effective to allow hybridization of the recognition oligonucleotides on the nanoparticles with the two or more portions of the nucleic acid; and

observing a detectable change brought about by hybridization of the recognition oligonucleotides on the nanoparticles with the nucleic acid.

25 315. A method of detecting nucleic acid having at least two portions comprising:

contacting the nucleic acid with at least two types of nanoparticles according to any one of Claims 253-263 having recognition oligonucleotides attached

thereto, the recognition oligonucleotides on the first type of nanoparticles comprising a sequence complementary to a first portion of the sequence of the nucleic acid, the recognition oligonucleotides on the second type of nanoparticles comprising a sequence complementary to a second portion of the sequence of the nucleic acid, the contacting
5 taking place under conditions effective to allow hybridization of the recognition oligonucleotides on the nanoparticles with the nucleic acid; and

observing a detectable change brought about by hybridization of the recognition oligonucleotides on the nanoparticles with the nucleic acid.

10 316. The method of Claim 315 wherein the contacting conditions include freezing and thawing.

317. The method of Claim 315 wherein the contacting conditions include heating.

15

318. The method of Claim 315 wherein the detectable change is observed on a solid surface.

319. The method of Claim 315 wherein the detectable change is a color change
20 observable with the naked eye.

320. The method of Claim 319 wherein the color change is observed on a solid surface.

25 321. The method of Claim 315 wherein the nanoparticles are metal nanoparticles or semiconductor nanoparticles.

322. The method of Claim 321 wherein the nanoparticles are made of gold.

323. The method of Claim 315 wherein the recognition oligonucleotides attached to the nanoparticles are labeled on their ends not attached to the nanoparticles with molecules that produce a detectable change upon hybridization of the recognition oligonucleotides on the nanoparticles with the nucleic acid.

324. The method of Claim 323 wherein the nanoparticles are metallic or semiconductor nanoparticles and the recognition oligonucleotides attached to the nanoparticles are labeled with fluorescent molecules.

10

325. The method of Claim 315 wherein:

the nucleic acid has a third portion located between the first and second portions, and the sequences of the oligonucleotides on the nanoparticles do not include sequences complementary to this third portion of the nucleic acid; and

15

the nucleic acid is further contacted with a filler oligonucleotide having a sequence complementary to this third portion of the nucleic acid, the contacting taking place under conditions effective to allow hybridization of the filler oligonucleotide with the nucleic acid.

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326. The method of Claim 315 wherein the nucleic acid is viral RNA or DNA.

327. The method of Claim 315 wherein the nucleic acid is a gene associated with a disease.

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328. The method of Claim 315 wherein the nucleic acid is a bacterial DNA.

329. The method of Claim 315 wherein the nucleic acid is a fungal DNA.

330. The method of Claim 315 wherein the nucleic acid is a synthetic DNA, a synthetic RNA, a structurally-modified natural or synthetic RNA, or a structurally-modified natural or synthetic DNA.

5 331. The method of Claim 315 wherein the nucleic acid is from a biological source.

332. The method of Claim 315 wherein the nucleic acid is a product of a polymerase chain reaction amplification.

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333. The method of Claim 315 wherein the nucleic acid is contacted with the first and second types of nanoparticles simultaneously.

334. The method of Claim 315 wherein the nucleic acid is contacted and
15 hybridized with the recognition oligonucleotides on the first type of nanoparticles before being contacted with the second type of nanoparticles.

335. The method of Claim 334 wherein the first type of nanoparticles is attached to a substrate.

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336. The method of Claim 315 wherein the nucleic acid is double-stranded and hybridization with the oligonucleotides on the nanoparticles results in the production of a triple-stranded complex.

25 337. A method of detecting a nucleic acid having at least two portions comprising:

(a) contacting the nucleic acid with a substrate having oligonucleotides attached thereto, the oligonucleotides having a sequence complementary to a first portion

of the sequence of said nucleic acid, the contacting taking place under conditions effective to allow hybridization of the oligonucleotides on the substrate with said nucleic acid;

5 (b) contacting said nucleic acid bound to the substrate with a first type of nanoparticle-oligonucleotide conjugates according to any one of Claims 237-240, at least one of the types of oligonucleotides attached to the nanoparticles of the conjugates having a sequence complementary to a second portion of the sequence of said nucleic acid, the contacting taking place under conditions effective to allow hybridization of the oligonucleotides attached to the nanoparticles of the conjugates with said nucleic acid;
10 and

(c) observing a detectable change.

338. The method of Claim 337 further comprising:

15 (d) contacting the first type of nanoparticle-oligonucleotide conjugates bound to the substrate with a second type of nanoparticle-oligonucleotide conjugates according to any one of Claims 237-240, at least one of the types of oligonucleotides attached to the nanoparticles of the second type of conjugates having a sequence complementary to the sequence of one of the types of oligonucleotides attached to the nanoparticles of the first type of conjugates, the contacting taking place under conditions
20 effective to allow hybridization of the oligonucleotides attached to the nanoparticles of the first and second types of conjugates; and

(e) observing the detectable change.

25 339. The method of Claim 338 wherein at least one of the types of oligonucleotides on the nanoparticles of the first type of conjugates has a sequence complementary to the sequence of at least one of the types of oligonucleotides on the nanoparticles of the second type of conjugates and the method further comprises:

(f) contacting the second type of conjugates bound to the substrate with

the first type of conjugates, the contacting taking place under conditions effective to allow hybridization of the oligonucleotides on the nanoparticles of the first and second types of conjugates; and

(g) observing the detectable change.

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340. The method of Claim 339 wherein step (d) or steps (d) and (f) are repeated one or more times and the detectable change is observed.

341. The method of Claim 337 further comprising:

10

(d) providing a type of binding oligonucleotides having a sequence comprising at least two portions, the first portion being complementary to at least one of the types of oligonucleotides attached to the nanoparticles of the first type of conjugates;

15

(e) contacting the binding oligonucleotides with the first type of conjugates bound to the substrate, the contacting taking place under conditions effective to allow hybridization of the binding oligonucleotides with the oligonucleotides on the nanoparticles of the first type of conjugates;

20

(f) providing a second type of nanoparticle-oligonucleotide conjugates according to any one of Claims 237-240, at least one of the types of oligonucleotides attached to the nanoparticles of the second type of conjugates having a sequence complementary to the second portion of the sequence of the binding oligonucleotides;

25

(g) contacting the binding oligonucleotides bound to the substrate with the second type of conjugates, the contacting taking place under conditions effective to allow hybridization of the oligonucleotides attached to the nanoparticles of the second type of conjugates with the binding oligonucleotides; and

(h) observing the detectable change.

342. The method of Claim 341 further comprising:

(i) contacting the second type of conjugates bound to the substrate with the

binding oligonucleotides, the contacting taking place under conditions effective to allow hybridization of the binding oligonucleotides with the oligonucleotides on the nanoparticles of the second type of conjugates;

5 (j) contacting the binding oligonucleotides bound to the substrate with the first type of conjugates, the contacting taking place under conditions effective to allow hybridization of the oligonucleotides on the nanoparticles of the first type of conjugates with the binding oligonucleotides; and

(k) observing the detectable change.

10 343. The method of Claim 342 wherein steps (e) and (g) or steps (e), (g), (i) and (j) are repeated one or more times, and the detectable change is observed.

344. The method of Claim 337 wherein the substrate is a transparent substrate or an opaque white substrate.

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345. The method of Claim 344 wherein the detectable change is the formation of dark areas on the substrate.

20 346. The method of Claim 337 wherein the nanoparticles of the conjugates are metal nanoparticles or semiconductor nanoparticles.

347. The method of Claim 346 wherein the nanoparticles of the conjugates are made of gold or silver.

25 348. The method of Claim 337 wherein the substrate has a plurality of types of oligonucleotides attached to it in an array to allow for the detection of multiple portions of a single nucleic acid, the detection of multiple different nucleic acids, or both.

349. The method of Claim 337 wherein the substrate is contacted with silver stain to produce the detectable change.

5 350. The method of Claim 348 wherein the substrate is contacted with silver stain to produce the detectable change.

351. The method of Claim 337 wherein the detectable change is observed with an optical scanner.

10 352. The method of Claim 351 wherein the device is a flatbed scanner.

353. The method of Claim 351 wherein the scanner is linked to a computer loaded with software capable of calculating greyscale measurements, and the greyscale measurements are calculated to provide a quantitative measure of the amount of nucleic acid detected.

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354. The method of Claim 337 wherein the oligonucleotides attached to the substrate are located between two electrodes, the nanoparticles of the conjugates are made of a material which is a conductor of electricity, and the detectable change is a change in conductivity.

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355. The method of Claim 354 wherein the electrodes are made of gold, and the nanoparticles are made of gold.

25 356. The method of Claim 354 wherein the substrate is contacted with silver stain to produce the change in conductivity.

357. The method of Claim 348 wherein each of the plurality of

oligonucleotides attached to the substrate in the array is located between two electrodes, the nanoparticles are made of a material which is a conductor of electricity, and the detectable change is a change in conductivity.

5 358. The method of Claim 357 wherein the electrodes are made of gold, and the nanoparticles are made of gold.

359. The method of Claim 357 wherein the substrate is contacted with silver stain to produce the change in conductivity.

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360. A method of detecting a nucleic acid having at least two portions comprising:

15 (a) contacting the nucleic acid with a substrate having oligonucleotides attached thereto, the oligonucleotides having a sequence complementary to a first portion of the sequence of said nucleic acid, the contacting taking place under conditions effective to allow hybridization of the oligonucleotides on the substrate with said nucleic acid;

20 (b) contacting said nucleic acid bound to the substrate with a first type of nanoparticles according to any one of Claims 243-250 having one or more types of recognition oligonucleotides attached thereto, at least one of the types of recognition oligonucleotides comprising a sequence complementary to a second portion of the sequence of said nucleic acid, the contacting taking place under conditions effective to allow hybridization of the oligonucleotides on the nanoparticles with said nucleic acid; and

25 (c) observing a detectable change.

361. The method of Claim 360 further comprising:

(d) contacting the first type of nanoparticles bound to the substrate with a

second type of nanoparticles according to any one of Claims 243-250 having recognition oligonucleotides attached thereto, at least one of the types of recognition oligonucleotides on the second type of nanoparticles comprising a sequence complementary to the sequence of one of the types of oligonucleotides on the first type of nanoparticles, the
5 contacting taking place under conditions effective to allow hybridization of the oligonucleotides on the first and second types of nanoparticles; and
(e) observing the detectable change.

362. The method of Claim 360 wherein at least one of the types of recognition
10 oligonucleotides on the first type of nanoparticles has a sequence complementary to the sequence of at least one of the types of oligonucleotides on the second type of nanoparticles and the method further comprises:

(f) contacting the second type of nanoparticles bound to the substrate with the first type of nanoparticles, the contacting taking place under conditions effective to
15 allow hybridization of the oligonucleotides on the first and second types of nanoparticles; and

(g) observing the detectable change.

363. The method of Claim 362 wherein step (d) or steps (d) and (f) are repeated
20 one or more times and the detectable change is observed.

364. The method of Claim 360 further comprising:

(d) providing a type of binding oligonucleotides having a sequence comprising at least two portions, the first portion being complementary to at least one of
25 the types of oligonucleotides on the first type of nanoparticles;

(e) contacting the binding oligonucleotides with the first type of nanoparticles bound to the substrate, the contacting taking place under conditions effective to allow hybridization of the binding oligonucleotides with the oligonucleotides

on the first type of nanoparticles;

(f) providing a second type of nanoparticles according to any one of Claims 243-250 having recognition oligonucleotides attached thereto, at least one of the types of recognition oligonucleotides on the second type of nanoparticles comprising a sequence complementary to the second portion of the sequence of the binding oligonucleotides;

(g) contacting the binding oligonucleotides bound to the substrate with the second type of nanoparticles, the contacting taking place under conditions effective to allow hybridization of the oligonucleotides on the second type of nanoparticles with the binding oligonucleotides; and

(h) observing the detectable change.

365. The method of Claim 364 further comprising:

(i) contacting the second type of nanoparticles bound to the substrate with the binding oligonucleotides, the contacting taking place under conditions effective to allow hybridization of the binding oligonucleotides with the oligonucleotides on the second type of nanoparticles;

(j) contacting the binding oligonucleotides bound to the substrate with the first type of nanoparticles, the contacting taking place under conditions effective to allow hybridization of the oligonucleotides on the first type of nanoparticles with the binding oligonucleotides; and

(k) observing the detectable change.

366. The method of Claim 365 wherein steps (e) and (g) or steps (e), (g), (i) and (j) are repeated one or more times, and the detectable change is observed.

367. The method of Claim 360 wherein the substrate is a transparent substrate or an opaque white substrate.

368. The method of Claim 367 wherein the detectable change is the formation of dark areas on the substrate.

5 369. The method of Claim 360 wherein the nanoparticles are metal nanoparticles or semiconductor nanoparticles.

370. The method of Claim 369 wherein the nanoparticles are made of gold or silver.

10

371. The method of Claim 360 wherein the substrate has a plurality of types of oligonucleotides attached to it in an array to allow for the detection of multiple portions of a single nucleic acid, the detection of multiple different nucleic acids, or both.

15 372. The method of Claim 360 wherein the substrate is contacted with silver stain to produce the detectable change.

373. The method of Claim 371 wherein the substrate is contacted with silver stain to produce the detectable change.

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375. The method of Claim 360 wherein the detectable change is observed with an optical scanner.

376. The method of Claim 375 wherein the device is a flatbed scanner.

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377. The method of Claim 375 wherein the scanner is linked to a computer loaded with software capable of calculating greyscale measurements, and the greyscale measurements are calculated, to provide a quantitative measure of the amount of nucleic

acid detected.

378. The method of Claim 360 wherein the oligonucleotides attached to the substrate are located between two electrodes, the nanoparticles are made of a material
5 which is a conductor of electricity, and the detectable change is a change in conductivity.

379. The method of Claim 378 wherein the electrodes are made of gold, and the nanoparticles are made of gold.

10 380. The method of Claim 378 wherein the substrate is contacted with silver stain to produce the change in conductivity.

381. The method of Claim 371 wherein each of the plurality of oligonucleotides attached to the substrate in the array is located between two electrodes,
15 the nanoparticles are made of a material which is a conductor of electricity, and the detectable change is a change in conductivity.

382. The method of Claim 381 wherein the electrodes are made of gold, and the nanoparticles are made of gold.

20

383. The method of Claim 381 wherein the substrate is contacted with silver stain to produce the change in conductivity.

25 384. A method of detecting a nucleic acid having at least two portions comprising:

(a) contacting the nucleic acid with a substrate having oligonucleotides attached thereto, the oligonucleotides having a sequence complementary to a first portion of the sequence of said nucleic acid, the contacting taking place under conditions

effective to allow hybridization of the oligonucleotides on the substrate with said nucleic acid;

5 (b) contacting said nucleic acid bound to the substrate with a first type of nanoparticles according to any one of Claims 253-263 having one or more types of recognition oligonucleotides attached thereto, at least one of the types of recognition oligonucleotides comprising a sequence complementary to a second portion of the sequence of said nucleic acid, the contacting taking place under conditions effective to allow hybridization of the recognition oligonucleotides on the nanoparticles with said nucleic acid; and

10 (c) observing a detectable change.

385. The method of Claim 384 further comprising:

15 (d) contacting the first type of nanoparticles bound to the substrate with a second type of nanoparticles according to any one of Claims 253-263 having recognition oligonucleotides attached thereto, at least one of the types of recognition oligonucleotides on the second type of nanoparticles comprising a sequence complementary to the sequence of one of the types of oligonucleotides on the first type of nanoparticles, the contacting taking place under conditions effective to allow hybridization of the oligonucleotides on the first and second types of nanoparticles; and

20 (e) observing the detectable change.

386. The method of Claim 385 wherein at least one of the types of recognition oligonucleotides on the first type of nanoparticles comprises a sequence complementary to the sequence of at least one of the types of oligonucleotides on the second type of nanoparticles and the method further comprises:

25 (f) contacting the second type of nanoparticles bound to the substrate with the first type of nanoparticles, the contacting taking place under conditions effective to allow hybridization of the oligonucleotides on the first and second types of nanoparticles;

and

(g) observing the detectable change.

387. The method of Claim 386 wherein step (d) or steps (d) and (f) are repeated
5 one or more times and the detectable change is observed.

388. The method of Claim 384 further comprising:

(d) providing a type of binding oligonucleotides having a sequence
comprising at least two portions, the first portion being complementary to at least one of
10 the types of oligonucleotides on the first type of nanoparticles;

(e) contacting the binding oligonucleotides with the first type of
nanoparticles bound to the substrate, the contacting taking place under conditions
effective to allow hybridization of the binding oligonucleotides with the oligonucleotides
on the first type of nanoparticles;

15 (f) providing a second type of nanoparticles according to any one of
Claims 253-263 having recognition oligonucleotides attached thereto, at least one of the
types of recognition oligonucleotides on the second type of nanoparticles comprising a
sequence complementary to the second portion of the sequence of the binding
oligonucleotides;

20 (g) contacting the binding oligonucleotides bound to the substrate with the
second type of nanoparticles, the contacting taking place under conditions effective to
allow hybridization of the oligonucleotides on the second type of nanoparticles with the
binding oligonucleotides; and

(h) observing the detectable change.

25

389. The method of Claim 388 further comprising:

(i) contacting the second type of nanoparticles bound to the substrate with
the binding oligonucleotides, the contacting taking place under conditions effective to

allow hybridization of the binding oligonucleotides with the oligonucleotides on the second type of nanoparticles;

(j) contacting the binding oligonucleotides bound to the substrate with the first type of nanoparticles, the contacting taking place under conditions effective to allow hybridization of the oligonucleotides on the first type of nanoparticles with the binding oligonucleotides; and

(k) observing the detectable change.

390. The method of Claim 389 wherein steps (e) and (g) or steps (e), (g), (i) and (j) are repeated one or more times, and the detectable change is observed.

391. The method of Claim 384 wherein the substrate is a transparent substrate or an opaque white substrate.

392. The method of Claim 391 wherein the detectable change is the formation of dark areas on the substrate.

393. The method of Claim 384 wherein the nanoparticles are metal nanoparticles or semiconductor nanoparticles.

394. The method of Claim 393 wherein the nanoparticles are made of gold or silver.

395. The method of Claim 384 wherein the substrate has a plurality of types of oligonucleotides attached to it in an array to allow for the detection of multiple portions of a single nucleic acid, the detection of multiple different nucleic acids, or both.

396. The method of Claim 384 wherein the substrate is contacted with silver

stain to produce the detectable change.

397. The method of Claim 395 wherein the substrate is contacted with silver stain to produce the detectable change.

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398. The method of Claim 384 wherein the detectable change is observed with an optical scanner

399. The method of Claim 398 wherein the device is a flatbed scanner.

10

400. The method of Claim 398 wherein the scanner is linked to a computer loaded with software capable of calculating greyscale measurements, and the greyscale measurements are calculated. to provide a quantitative measure of the amount of nucleic acid detected.

15

401. The method of Claim 384 wherein the oligonucleotides attached to the substrate are located between two electrodes, the nanoparticles are made of a material which is a conductor of electricity, and the detectable change is a change in conductivity.

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402. The method of Claim 401 wherein the electrodes are made of gold, and the nanoparticles are made of gold.

403. The method of Claim 401 wherein the substrate is contacted with silver stain to produce the change in conductivity.

25

404. The method of Claim 397 wherein each of the plurality of oligonucleotides attached to the substrate in the array is located between two electrodes, the nanoparticles are made of a material which is a conductor of electricity, and the

detectable change is a change in conductivity.

405. The method of Claim 404 wherein the electrodes are made of gold, and the nanoparticles are made of gold.

5

406. The method of Claim 404 wherein the substrate is contacted with silver stain to produce the change in conductivity.

407. A method of detecting a nucleic acid having at least two portions
10 comprising:

(a) contacting the nucleic acid with a substrate having oligonucleotides attached thereto, the oligonucleotides being located between a pair of electrodes, the oligonucleotides having a sequence complementary to a first portion of the sequence of said nucleic acid, the contacting taking place under conditions effective to allow
15 hybridization of the oligonucleotides on the substrate with said nucleic acid;

(b) contacting said nucleic acid bound to the substrate with a first type of nanoparticles, the nanoparticles being made of a material which can conduct electricity, the nanoparticles having one or more types of oligonucleotides attached thereto, at least one of the types of oligonucleotides having a sequence complementary to a second
20 portion of the sequence of said nucleic acid, the contacting taking place under conditions effective to allow hybridization of the oligonucleotides on the nanoparticles with said nucleic acid; and

(c) detecting a change in conductivity.

408. The method of Claim 407 wherein the substrate has a plurality of pairs of
25 electrodes located on it in an array to allow for the detection of multiple portions of a single nucleic acid, the detection of multiple different nucleic acids, or both, each of the pairs of electrodes having a type of oligonucleotides attached to the substrate between

them.

409. The method of Claim 407 wherein the nanoparticles are made of metal.

5 410. The method of Claim 407 wherein the nanoparticles are made of gold or silver.

411. The method of Claim 407 wherein the substrate is contacted with silver stain to produce the change in conductivity.

10

412. The method of Claim 407 further comprising:

(d) contacting the first type of nanoparticles bound to the substrate with a second type of nanoparticles, the nanoparticles being made of a material which can conduct electricity, the nanoparticles having oligonucleotides attached thereto, at least
15 one of the types of oligonucleotides on the second type of nanoparticles comprising a sequence complementary to the sequence of one of the types of oligonucleotides on the first type of nanoparticles, the contacting taking place under conditions effective to allow hybridization of the oligonucleotides on the first and second types of nanoparticles; and
(e) detecting the change in conductivity.

20

413. The method of Claim 412 wherein at least one of the types of oligonucleotides on the first type of nanoparticles has a sequence complementary to the sequence of at least one of the types of oligonucleotides on the second type of nanoparticles and the method further comprises:

25 (f) contacting the second type of nanoparticles bound to the substrate with the first type of nanoparticles, the contacting taking place under conditions effective to allow hybridization of the oligonucleotides on the first and second types of nanoparticles; and

(g) detecting the change in conductivity.

414. The method of Claim 413 wherein step (d) or steps (d) and (f) are repeated one or more times and the change in conductivity is detected.

5

415 The method of Claim 407 further comprising:

(d) contacting the first type of nanoparticles bound to the substrate with an aggregate probe having oligonucleotides attached thereto, the nanoparticles of the aggregate probe being made of a material which can conduct electricity, at least one of
10 the types of oligonucleotides on the aggregate probe comprising a sequence complementary to the sequence of one of the types of oligonucleotides on the first type of nanoparticles, the contacting taking place under conditions effective to allow hybridization of the oligonucleotides on the aggregate probe with the oligonucleotides on the first type of nanoparticles;

15

(e) and detecting the change in conductivity.

416. A method of detecting nucleic acid having at least two portions comprising:

(a) contacting a nucleic acid with a substrate having oligonucleotides
20 attached thereto, the oligonucleotides being located between a pair of electrodes, the oligonucleotides having a sequence complementary to a first portion of the sequence of said nucleic acid, the contacting taking place under conditions effective to allow hybridization of the oligonucleotides on the substrate with said nucleic acid;

(b) contacting said nucleic acid bound to the substrate with an aggregate
25 probe having oligonucleotides attached thereto, at least one of the types of oligonucleotides on the aggregate probe comprising a sequence complementary to the sequence of a second portion of said nucleic acid, the nanoparticles of the aggregate probe being made of a material which can conduct electricity, the contacting taking place

under conditions effective to allow hybridization of the oligonucleotides on the aggregate probe with the nucleic acid; and

(c) detecting a change in conductivity.

5 417. A method of detecting a nucleic acid wherein the method is performed on a substrate, the method comprising detecting the presence, quantity, or both, of the nucleic acid with an optical scanner.

418. The method of Claim 417 wherein the device is a flatbed scanner.

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419. The method of Claim 417 wherein the scanner is linked to a computer loaded with software capable of calculating greyscale measurements, and the greyscale measurements are calculated. to provide a quantitative measure of the amount of nucleic acid detected.

15

420. The method of Claim 417 wherein the scanner is linked to a computer loaded with software capable of providing an image of the substrate, and a qualitative determination of the presence of the nucleic acid, the quantity of the nucleic acid, or both, is made.

20

421. A kit comprising a container holding nanoparticle-oligonucleotide conjugates according to any one of Claims 237-242.

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422. A kit comprising a container holding nanoparticles according to any one of Claims 243-265.

423. A kit comprising a substrate having attached thereto at least one pair of electrodes with oligonucleotides attached to the substrate between the electrodes.

424. The kit of Claim 423 wherein the substrate has a plurality of pairs of electrodes attached to it in an array, to allow for the detection of multiple portions of a single nucleic acid, the detection of multiple different nucleic acids, or both.

5

425. A method of nanofabrication comprising
providing at least one type of linking oligonucleotide having a selected sequence, the sequence of each type of linking oligonucleotide having at least two portions;

10 providing one or more types of nanoparticle-oligonucleotide conjugates according to any one of Claims 237-242, the oligonucleotides attached to the nanoparticles of each of the types of conjugates having a sequence complementary to the sequence of a portion of a linking oligonucleotide; and

15 contacting the linking oligonucleotides and conjugates under conditions effective to allow hybridization of the oligonucleotides attached to the nanoparticles of the conjugates to the linking oligonucleotides so that a desired nanomaterial or nanostructure is formed wherein the nanoparticles of the conjugates are held together by oligonucleotide connectors.

20 426. A method of nanofabrication comprising
providing at least one type of linking oligonucleotide having a selected sequence, the sequence of each type of linking oligonucleotide having at least two portions;

25 providing one or more types of nanoparticles according to any one of Claims 243-265, the recognition oligonucleotides on each of the types of nanoparticles comprising a sequence complementary to the sequence of a portion of a linking oligonucleotide; and

contacting the linking oligonucleotides and nanoparticles under conditions

effective to allow hybridization of the oligonucleotides on the nanoparticles to the linking oligonucleotides so that a desired nanomaterial or nanostructure is formed wherein the nanoparticles are held together by oligonucleotide connectors.

- 5 427. A method of nanofabrication comprising:
 providing at least two types of nanoparticle-oligonucleotide conjugates
 according to any one of Claims 237-242,
 the oligonucleotides attached to the nanoparticles of the first type of
 conjugates having a sequence complementary to that of the oligonucleotides attached to
10 the nanoparticles of the second type of conjugates;
 the oligonucleotides attached to the nanoparticles of the second type of
 conjugates having a sequence complementary to that of the oligonucleotides attached to
 the nanoparticles of the first type of conjugates; and
 contacting the first and second types of conjugates under conditions
15 effective to allow hybridization of the oligonucleotides on the nanoparticles of the
 conjugates to each other so that a desired nanomaterial or nanostructure is formed.

428. A method of nanofabrication comprising:
 providing at least two types of nanoparticles according to any one of
20 Claims 243-265,
 the recognition oligonucleotides on the first type of nanoparticles
 comprising a sequence complementary to that of the oligonucleotides on the second of
 the nanoparticles;
 the recognition oligonucleotides on the second type of nanoparticles
25 comprising a sequence complementary to that of the oligonucleotides on the first type of
 nanoparticles; and
 contacting the first and second types of nanoparticles under conditions
 effective to allow hybridization of the oligonucleotides on the nanoparticles to each other

so that a desired nanomaterial or nanostructure is formed.

429. Nanomaterials or nanostructures composed of nanoparticle-oligonucleotide conjugates according to any one of Claims 237-242, the nanoparticles
5 being held together by oligonucleotide connectors.

430. Nanomaterials or nanostructures composed of nanoparticles according to any one of Claims 243-265, the nanoparticles being held together by oligonucleotide connectors.

10

431. A method of separating a selected nucleic acid having at least two portions from other nucleic acids, the method comprising:

providing two or more types of nanoparticle-oligonucleotide conjugates according to any one of Claims 237-242, the oligonucleotides attached to the
15 nanoparticles of each of the types of conjugates having a sequence complementary to the sequence of one of the portions of the selected nucleic acid; and

contacting the nucleic acids and conjugates under conditions effective to allow hybridization of the oligonucleotides on the nanoparticles of the conjugates with the selected nucleic acid so that the conjugates hybridized to the selected nucleic acid
20 aggregate and precipitate.

432. A method of separating a selected nucleic acid having at least two portions from other nucleic acids, the method comprising:

providing two or more types of nanoparticles according to any one of
25 Claims 243-265, the oligonucleotides on each of the types of nanoparticles having a sequence complementary to the sequence of one of the portions of the selected nucleic acid; and

contacting the nucleic acids and nanoparticles under conditions effective

to allow hybridization of the oligonucleotides on the nanoparticles with the selected nucleic acid so that the nanoparticles hybridized to the selected nucleic acid aggregate and precipitate.

5 433. Nanoparticle-oligonucleotide conjugates which are nanoparticles having oligonucleotides attached to them, the oligonucleotides having a covalently bound cyclic disulfide functional group that can bind to the nanoparticles.

10 434. Nanoparticle-oligonucleotide conjugates which are nanoparticles having oligonucleotides attached to them, the oligonucleotides having a covalently bound polythiol functional group that can bind to the nanoparticles.

15 435. Nanoparticle-oligonucleotide conjugates which are nanoparticles having oligonucleotides attached to them, the oligonucleotides having a covalently bound cyclic disulfide functional group that can bind to the nanoparticles, at least some of the oligonucleotides having a sequence complementary to at least one portion of the sequence of a nucleic acid or another oligonucleotide.

20 436. Nanoparticle-oligonucleotide conjugates which are nanoparticles having oligonucleotides attached to them, the oligonucleotides having a covalently bound polythiol functional group that can bind to the nanoparticles, at least some of the oligonucleotides having a sequence complementary to at least one portion of the sequence of a nucleic acid or another oligonucleotide.

25 437. The conjugates of claims 435 or 436 wherein the oligonucleotides are further present at a surface density sufficient so that the conjugates are stable.

438. The conjugates of claim 437 wherein the oligonucleotides are present on

surface of the nanoparticles at a surface density of at least 10 picomoles/cm²

439. The conjugates of claim 438 wherein the oligonucleotides are present on surface of the nanoparticles at a surface density of at least 15 picomoles/cm².

5

440. The conjugates of claim 439 wherein the oligonucleotides are present on surface of the nanoparticles at a surface density of from about 15 picomoles/cm² to about 40 picomoles/cm².

10

441. The conjugates of claims 435 or 436 wherein the nanoparticles are metal nanoparticles or semiconductor nanoparticles.

442. The conjugates of claim 441 wherein the nanoparticles are gold nanoparticles.

15

443. The conjugates of claims 435 or 436 wherein the oligonucleotides comprise at least one type of recognition oligonucleotides, the recognition portion having a sequence complementary to at least one portion of the sequence of a nucleic acid or another oligonucleotide.

20

444. The conjugates of claim 443 wherein each of the recognition oligonucleotides comprising a spacer portion and a recognition portion, the spacer portion being designed so that it is bound to the nanoparticles,

25

445. The conjugates of claim 444 wherein the spacer portion has a moiety covalently bound to it, the moiety comprising a cyclic disulfide functional group through which the spacer portion is bound to the nanoparticles.

446. The conjugates of claim 444 wherein the spacer portion has a moiety covalently bound to it, the moiety comprising a polythiol functional group through which the spacer portion is bound to the nanoparticles.

5 447. The conjugates of claim 442 wherein the spacer portion comprises at least about 10 nucleotides.

448. The conjugates of claim 447 wherein the spacer portion comprises from about 10 to about 30 nucleotides.

10

449. The conjugates of claim 448 wherein the bases of the nucleotides of the spacer portion are all adenines, all thymines, all cytosines, all uracils or all guanines.

450. The conjugates of claims 435 or 436 further a type of diluent
15 oligonucleotides.

451. The nanoparticles of claim 450 wherein the diluent oligonucleotides contain about the same number of nucleotides as are contained in the spacer portions of the recognition oligonucleotides.

20

452. The nanoparticles of claim 451 wherein the sequence of the diluent oligonucleotides is the same as that of the spacer portions of the recognition oligonucleotides.

25 453. A method of binding oligonucleotides to nanoparticles to produce nanoparticle-oligonucleotide conjugates, the method comprising:

 providing oligonucleotides having covalently bound cyclic disulfide function groups that can bind to nanoparticles; and

contacting the oligonucleotides and the nanoparticles under conditions effective to allow at least some of the oligonucleotides to bind to the nanoparticles to produce the nanoparticle-oligonucleotide conjugates.

5 454. A method of binding oligonucleotides to nanoparticles to produce nanoparticle-oligonucleotide conjugates, the method comprising:

 providing oligonucleotides having covalently bound polythiol function groups that can bind to nanoparticles; and

 contacting the oligonucleotides and the nanoparticles under conditions
10 effective to allow at least some of the oligonucleotides to bind to the nanoparticles to produce the nanoparticle-oligonucleotide conjugates.

 455. The method of claims 454 or 455 wherein the nanoparticles are metal nanoparticles or semiconductor nanoparticles.

15

 456. The method of claim 455 wherein the nanoparticles are gold nanoparticles.

 457. The method of claims 453 or 454 wherein, the oligonucleotides comprising at least one type of recognition oligonucleotides, each of the recognition
20 oligonucleotides comprising a spacer portion and a recognition portion, the spacer portion having a moiety covalently bound thereto, the moiety comprising a functional group which can bind to the nanoparticles.

 458. The method of claim 457 wherein the spacer portion comprises at least
25 about 10 nucleotides.

 459. The method of claims 458 wherein the spacer portion comprises from about 10 to about 30 nucleotides.

460. The method of claims 459 wherein the bases of the nucleotides of the spacer are all adenines, all thymines, all cytosines, all uracils, or all guanines.

5 461. The method of claim 457, wherein the oligonucleotides further comprising a type of diluent oligonucleotides and contacting the oligonucleotides with the nanoparticles under conditions effective to allow at least some of each of the types of oligonucleotides to bind to the nanoparticles to produce the nanoparticle-oligonucleotide conjugates.

10

462. The method of claim 461 wherein the diluent oligonucleotides contain about the same number of nucleotides as are contained in the spacer portions of the recognition oligonucleotides.

15

463. The method of claim 462 wherein the sequence of the diluent oligonucleotides is the same as the sequence of the spacer portions of the recognition oligonucleotides.

20 464. The method of claim 457 wherein the oligonucleotides comprise at least two types of recognition oligonucleotides.

465. A method of binding oligonucleotides to charged nanoparticles to produce nanoparticle-oligonucleotide conjugates, the method comprising:

25 providing oligonucleotides having covalently bound cyclic disulfide function groups that can bind to nanoparticles, the oligonucleotides comprising:

 a type of recognition oligonucleotides; and

 a type of diluent oligonucleotides;

 contacting the oligonucleotides with the nanoparticles in water for a period

of time sufficient to allow at least some of each of the types of oligonucleotides to bind to the nanoparticles;

5 adding at least one salt to the water to form a salt solution, the ionic strength of the salt solution being sufficient to overcome at least partially the electrostatic attraction or repulsion of the oligonucleotides for the nanoparticles and the electrostatic repulsion of the oligonucleotides for each other; and

10 contacting the oligonucleotides and nanoparticles in the salt solution for an additional period of time sufficient to allow additional oligonucleotides of each of the types of oligonucleotides to bind to the nanoparticles to produce the nanoparticle-oligonucleotide conjugates.

466. A method of binding oligonucleotides to charged nanoparticles to produce nanoparticle-oligonucleotide conjugates, the method comprising:

15 providing oligonucleotides having covalently bound polythiol function groups that can bind to nanoparticles, the oligonucleotides comprising:

a type of recognition oligonucleotides; and

a type of diluent oligonucleotides;

20 contacting the oligonucleotides with the nanoparticles in water for a period of time sufficient to allow at least some of each of the types of oligonucleotides to bind to the nanoparticles;

adding at least one salt to the water to form a salt solution, the ionic strength of the salt solution being sufficient to overcome at least partially the electrostatic attraction or repulsion of the oligonucleotides for the nanoparticles and the electrostatic repulsion of the oligonucleotides for each other; and

25 contacting the oligonucleotides and nanoparticles in the salt solution for an additional period of time sufficient to allow additional oligonucleotides of each of the types of oligonucleotides to bind to the nanoparticles to produce the nanoparticle-oligonucleotide conjugates.

467. The method of claims 465 or 466 wherein the nanoparticles are metal nanoparticles or semiconductor nanoparticles.

5 468. The method of claims 467 wherein the nanoparticles are gold nanoparticles.

469. The method of claims 465 or 466 wherein all of the salt is added to the water in a single addition.

10

470. The method of claims 465 or 466 wherein the salt is added gradually over time.

471. The method of claims 465 or 466 wherein the salt is selected from the
15 group consisting of sodium chloride, magnesium chloride, potassium chloride, ammonium, chloride, sodium, acetate, ammonium acetate, a combination of two or more of these salts, one of these salts in a phosphate buffer, and a combination of two or more these salts in a phosphate buffer.

20 472. The method of claim 471 wherein the salt is sodium chloride in a phosphate buffer.

473. The method of claims 465 or 466 wherein nanoparticle-oligonucleotide conjugates are produced which have the oligonucleotides are present on surface of the
25 nanoparticles at a surface density of at least 10 picomoles/cm².

474. The method of claim 473 wherein the oligonucleotides are present on surface of the nanoparticles at a surface density of at least 15 picomoles/cm².

475. The method of claim 474 wherein the oligonucleotides are present on surface of the nanoparticles at a surface density of from about 15 picomoles/cm² to about 40 picomoles/cm².

5

476. The method of claim 465 wherein each of the recognition oligonucleotides comprises a spacer portion and a recognition portion, the spacer portion having attached to it the moiety comprising a cyclic disulfide functional group which can bind to the nanoparticles.

10

477. The method of claim 466 wherein each of the recognition oligonucleotides comprises a spacer portion and a recognition portion, the spacer portion having attached to it the moiety comprising a polythiol functional group which can bind to the nanoparticles.

15

478. The method of claims 476 or 477 wherein the spacer portion comprises at least about 10 nucleotides.

479. The method of claim 478 wherein the spacer portion comprises from about 10 to about 30 nucleotides.

20

480. The method of claims 476 or 477 wherein the bases of the nucleotides of the spacers are all adenines, all thymines, all cytosines, all uracils, or all guanines.

481. The method of claims 476 or 477 wherein the diluent oligonucleotides contain about the same number of nucleotides as are contained in the spacer portions of the recognition oligonucleotides.

25

482. The method of claim 481 wherein the sequence of the diluent oligonucleotides is the same as the sequence of the spacer portions of the recognition oligonucleotides.

5 483. The method of claims 476 or 477 wherein the oligonucleotides comprise at least two types of recognition oligonucleotides.

484. Oligonucleotides having a covalently bound cyclic disulfide functional group that can bind to the nanoparticles.

10

485. Oligonucleotides having a covalently bound polythiol functional group that can bind to the nanoparticles.

15 486. The compositions according to claims 433, 435, 445, 446, 453, 465, and 484 wherein a large hydrophobic group is located between the oligonucleotide and the cyclic disulfide functional group.